1104

DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D. C. 20390

FAC 0423B1/MJS:ejn
5100.26
Ser: 302

5 AUG 1971

From: Commander, Naval Facilities Engineering Command
To: Commander, Naval Undersea Research and Development Center, San Diego, California

Subj: Byproduct Material License No. 04-13495-01; Cancellation of

Ref: (a) NAVFAC ltr FAC 0423B1/MJS:srs 5100.26 ser: 282 of 21 July 1971
(b) NURDC ltr 1104/ALS:vh 10330 ser: 1104-21 of 14 July 71

Encl: (1) Copy, AEC ltr DML:RLS 04-13495-01 of 29 July 1971

1. The Atomic Energy Commission has cancelled the subject license in response to the requests of references (a) and (b). A copy of the termination notice is forwarded as enclosure (1) for information and retention.

R. E. Carlton

R. E. CARLTON
Head, Nuclear Safety Branch
By direction

1104
10330
JD

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

JUL 29 1971

DML:RLS
4-13495-1

Department of the Navy
ATTN: Mr. R. E. Carlton
Naval Facilities Engineering
Command
Washington, D.C. 20390

Gentlemen:

Pursuant to your letter dated July 21, 1971, Byp License No. 4-13495-1 issued to the Naval Undersea Research and Development Center is hereby terminated.

FOR THE ATOMIC ENERGY COMMISSION

Donald A. Nussbaumer

Donald A. Nussbaumer, Chief
Fuel Fabrication and
Transportation Branch
Division of Materials Licensing

Enclosure (-)

1104

DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D. C. 20390

FAC 0423B1/MJS:srs
5100.26
Ser: 288

21 JUL 1971

Gentlemen:

A certificate of disposition of the radioisotopes under Byproduct Material License 04-13495-01 is submitted by the Naval Undersea Research and Development Center (NURDC) and forwarded herewith in response to your letter DML:1B:36 of July 1, 1971. This command concurs with the enclosed request for cancellation of the aforementioned license.

Sincerely,

R. E. CARLTON
Head, Nuclear Safety Branch
By direction

1104
10330
SD

U. S. Atomic Energy Commission
Division of Materials Licensing
Washington, D. C. 20545

Enclosure: NURDC ltr 1104/ALS:vh 10330 Ser: 1104-21 of 14 July 71

Copy to: wo/encl
NURDC

1104

DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D. C. 20390

FAC 0423B/CR:srs
5100.26
Ser: 271

9 JUL 1971

From: Commander, Naval Facilities Engineering Command
To: Commander, Naval Undersea Research and Development Center
San Diego, California

Subj: Byproduct Material License 4-13495-1; amendment of, for use of Sugarman Cask for shipment of SNAP 21 capsules

Ref: (a) NAVFAC ltr 042 042/0423B 5100.26 Ser 232 of 14 Jun 71 recd
(b) NURDC ltr 10330 Ser 1104-9 of 3 May 71
(c) NAVFAC ltr 0423B1 5100.26 Ser 268 of 8 Jul 71 recd

Encl: (1) NURDC ltr 10330 Ser 1104-16 of 15 Jun 71 to 1104

1. As a result of the requests in references (a) and (b), the Atomic Energy Commission has issued the subject amendment which was forwarded by reference (c).

2. References (a) and (b) were sufficient to justify the request for the subject amendment. Therefore, the supplementary information furnished in enclosure (1) was not required and is returned herewith.

11 / 1104 / 10330 / SD

R. E. Carlton

R. E. CARLTON

[illegible]
Head, Nuclear Safety Branch
By direction

DEPARTMENT OF THE NAVY
NAVAL UNDERSEA RESEARCH AND DEVELOPMENT CENTER
SAN DIEGO, CALIFORNIA 92132

IN REPLY REFER TO:
1104/ALS:vh
10330
Ser: 1104-16
15 JUN 1971

From: Commander, Naval Undersea Research and Development Center
To: Chief, Division of Materials Licensing, U. S. Atomic Energy Commission, Washington, D. C. 20545
Via: Commander, Naval Facilities Engineering Command, Code 042

Subj: Byproduct Material License 4-13495-1; request for amendment of

Ref: (a) Handbook of Shielding Requirements and Radiation Characteristics of Isotopic Power Sources for Terrestrial, Marine and Space Applications, ORNL-3576
(b) NUC ltr 1104/ALS:vh, 10330, Ser: 1104-9 dtd 3 May 1971

Encl: (1) Sketch of ORNL Sugarman Cask and Fire and Impact Shield (DOT SP-5725)

1. The subject license authorized the shipment of the two SNAP-21 fuel capsules covered by the license in the ORNL Type M shipping cask, (DOT SP-5595) upon completion of the tests. In view of an existing unavailability of the Type M Cask, the ORNL proposes to substitute two ORNL Sugarman Cask and Fire and Impact Shields (DOT SP-7525) for the shipment. A sketch of the Sugarman cask assembly is submitted as enclosure (1). It is noted the allowable thermal loading of the cask is 200 watts. Each of the SNAP-21 capsules has a heat output of 186 watts.

2. Oak Ridge National Laboratory drawings DRD 2329 and DRD 2533 provide more detailed information concerning cask design. Copies of these are being forwarded to you by ORNL.

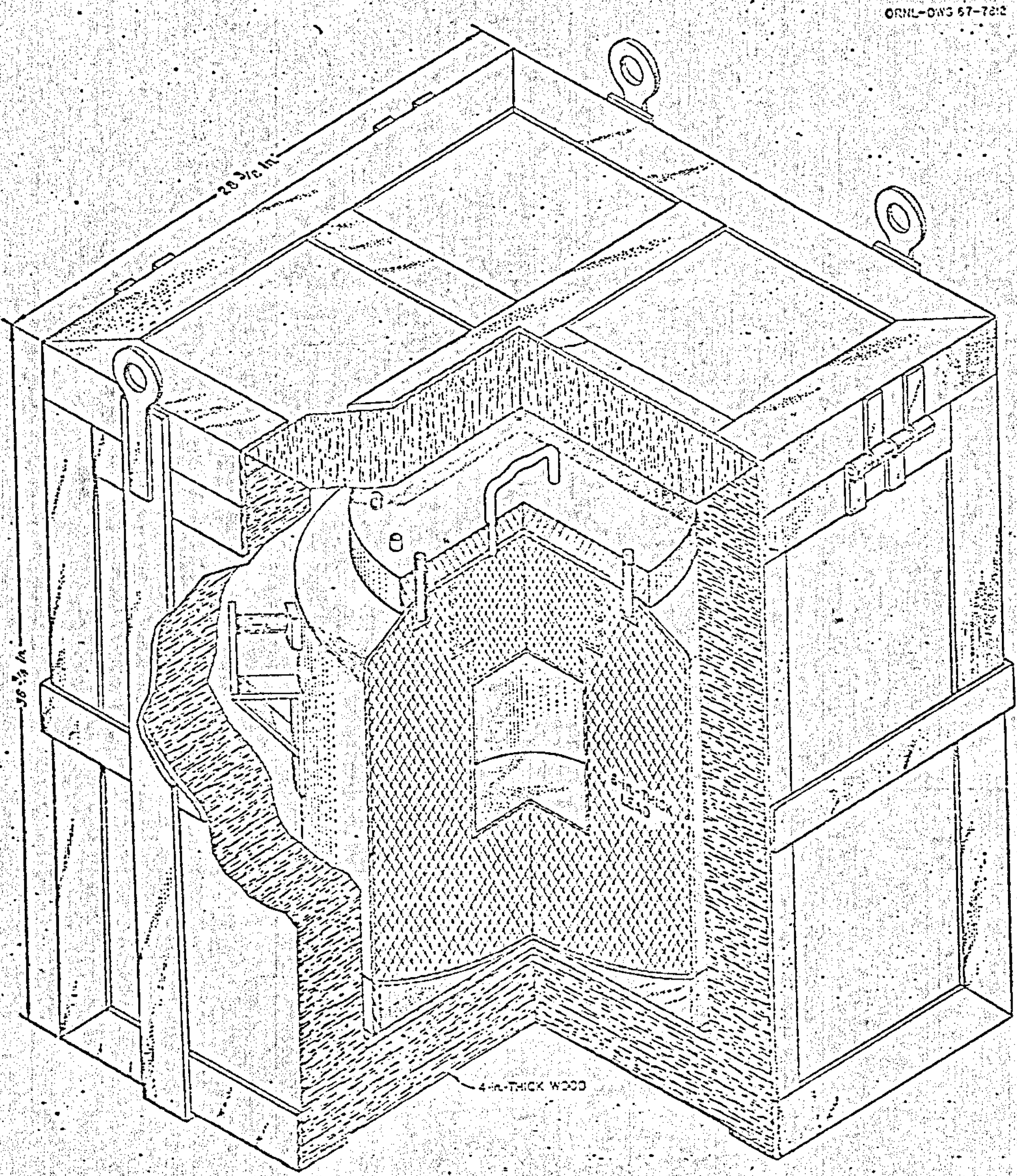
3. Using reference (a) as a guide, the dose-rates exterior to the shipping cask with the 30,000 curies of strontium-90 contained are expected to be 16 mr/hr at the surface and 1 mr/hr at one meter.

4. This letter, with corrected and additional information will replace and supersede reference (b).

George W. Coulter
GEORGE W. COULTER
By direction

DOT SP 5725

Shipping Wt 3000 lbs

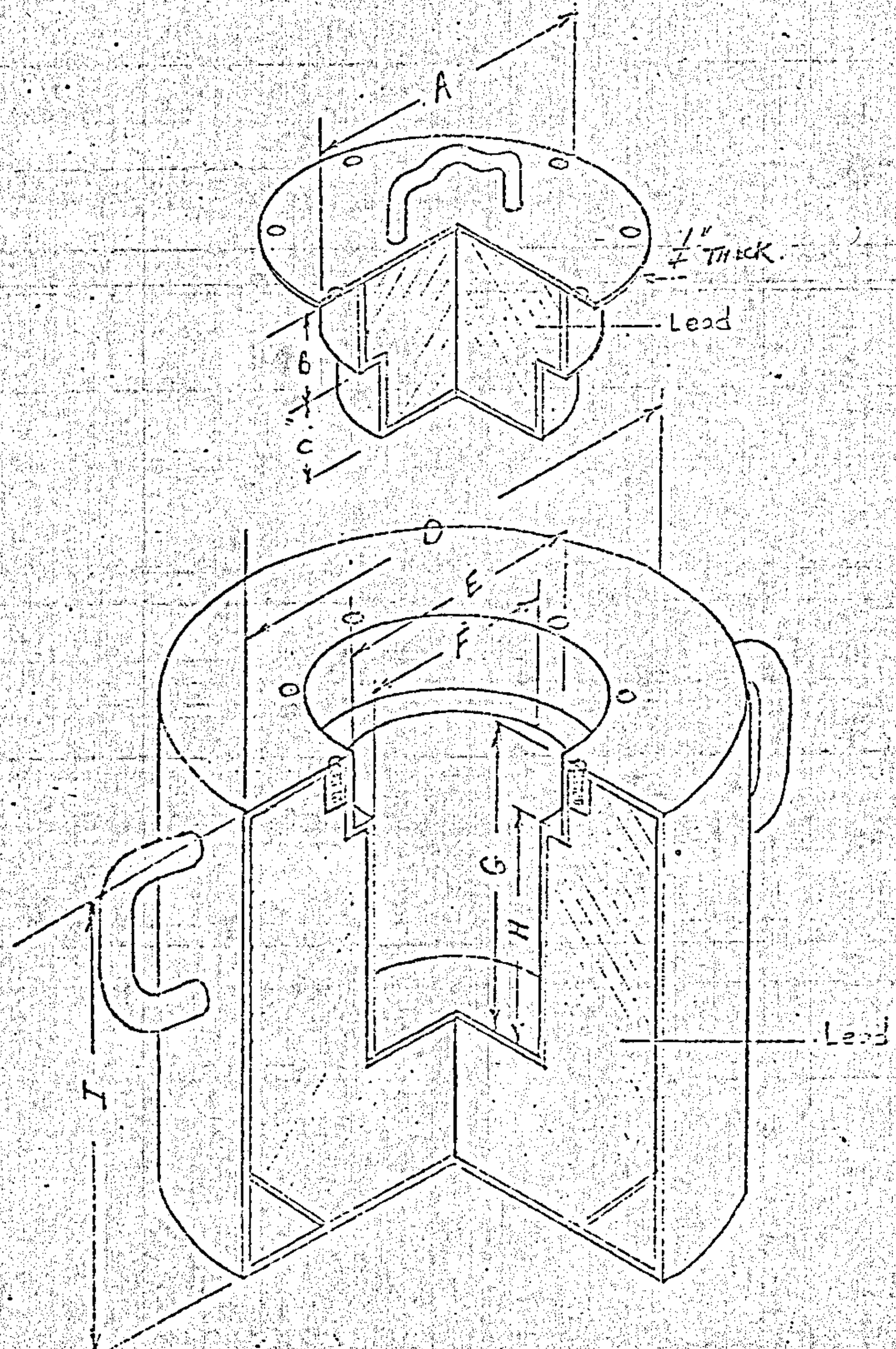


SUGARMAN SHIPPING CASK WITH WOODEN FIRE AND IMPACT SHIELD

RETURNABLE CONTAINER FOR SOLID MATERIALS SERIES S-10

O.R.N.L. 12/18/54 | T.E.W.

Type	A	B	C	D	E	F	G	H	I
1490 lb.	11½"	2½"	2½"	17"	8 27/32"	7 7/8"	10"	7½"	14½
2250 lb.	14¾"	4"	2"	20"	9¼"	7¼"	14½	10½"	23 7/16



1104

DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D. C. 20390

FAC 0423B1/MJS:srs
5100.26 Ser: 268
8 JUL 1971

From: Commander, Naval Facilities Engineering Command
To: Commander, Naval Undersea Research and Development Center
San Diego, California

Subj: Amendment to AEC Byproduct Material License No. 4-13495-1

Ref: (a) NAVFAC ltr FAC 042/0423B 5100.26 Ser: 232 of 14 June 1971 field
(b) NURDC ltr 10330 Ser: 1104-9 of 3 May 1971

Encl: (1) Amendment No. 71-2 to AEC Byproduct Material License No. 4-13495-1

1. The Atomic Energy Commission has approved the request in references (a) and (b) authorizing the use of the ORNL Sugarman Cask for the transportation of Snap 21 fuel capsules and has issued enclosure (1), which is forwarded for your use and retention.

R. E. Carlton

R. E. CARLTON
Head, Nuclear Safety Branch
By direction

1/1104
1033.0
SD

042

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

JUN 24 1971

DML:CEM
4-13495-1, Amendment No. 1
4-13495-1, Amendment No. 71-2

Department of the Navy
ATTN: Mr. T. F. Jones
Naval Facilities Engineering Command
Washington, D. C. 20390

Gentlemen:

Pursuant to Title 10, Code of Federal Regulations, Parts 30, 40, and 71, Item 4 of Amendment No. 1 to License No. 4-13495-1, dated October 31, 1969, is hereby amended to read as follows:

4. Oak Ridge National Laboratory Uranium Shielded Cask, Model M or ORNL Sugarman Cask and Fire and Impact Shield.

All other conditions of this license shall remain the same.

Enclosed is Amendment No. 71-2 to License No. 4-13495-1 authorizing the delivery of large quantity radioactive material to a carrier for transport in the ORNL Sugarman Cask. Please note that this amendment does not authorize the transport of radioactive material. Such transport is normally subject to regulation by the Department of Transportation (DOT).

FOR THE ATOMIC ENERGY COMMISSION

Donald A. Nussbaumer

Donald A. Nussbaumer, Chief
Fuel Fabrication and
Transportation Branch
Division of Materials Licensing

Enclosure:
Amend. No. 71-2

cc: Mr. Alfred W. Grella
Department of Transportation

Form AEC-401a
(7/70)

UNITED STATES
ATOMIC ENERGY COMMISSION

JUN 24 1971

- - - - - -

LICENSE AMENDMENT
for
DELIVERY OF RADIOACTIVE MATERIAL
to a
CARRIER FOR TRANSPORT

Pursuant to the Atomic Energy Act of 1954 and Title 10, Chapter 1, Code of Federal Regulations, Part 30, "Rules of General Applicability to Licensing of Byproduct Material", Part 70, "Special Nuclear Material", as appropriate, and Part 71, "Packaging of Radioactive Material for Transport", the following amendment to the license identified below is hereby issued, authorizing the licensee to deliver radioactive material to a carrier for transport, and is subject to the conditions specified in that license and to the conditions specified below:

LICENSEE		
1. Name:	Department of the Navy	3. License No. 4-13495-1
2. Address:	Naval Undersea Research and Development Center San Diego, California 92132	Amendment No. 71-2

CONDITIONS

4. (a) Packaging

(1) Model number — Sugarman Cask/Overpack

(2) Description — A DOT Specification 55, metal-encased, lead or uranium metal shielded radioactive material container within a wooden fire and impact shield. The shield provides at least 4-inches of wood for fire and impact protection for the Spec. 55 container. The maximum weight of the container and shield shall not exceed 3000 pounds. The fire and impact shield is constructed in accordance with ORNL Drawing D-RD-2533, Rev. C.

(b) Contents

(1) Type and form of material — SNAP-21 fuel capsules containing strontium titanate.

4. (b) Contents continued.

(2) Maximum quantity of material per package	One (1) fuel capsule with a maximum decay heat generation not to exceed 200 watts.

5. Fuel capsules which have been exposed to an ocean environment shall be contained within the inner container described in Enclosure 1 of the application supplement dated August 8, 1968 (9900 Ser: 192-0516), in addition to the packaging specified in Item 4(a).

6. The DOT Specification 55 container must be securely positioned and shored within the overpack to preclude movement during transport.

REFERENCES

Licensee's application dated May 26, 1971, as supplemented June 14, 1971 requesting approval to deliver large quantity radioactive material to a carrier for transport in the ORNL Sugarman Cask and Fire and Impact Shield.

R. T. Lauer and R. D. Seagren, Evaluation of Two Wood Fire and Impact Shields, CONF 681001, Proceedings of the Second International Symposium on Packaging and Transportation of Radioactive Materials.

FOR THE ATOMIC ENERGY COMMISSION

Date of Amendment JUN 24 1971

Donald A. Nussbaumer

Donald A. Nussbaumer
Division of Materials Licensing

1104

DEPARTMENT OF THE NAVY
NAVAL UNDERSEA RESEARCH AND DEVELOPMENT CENTER
SAN DIEGO, CALIFORNIA 92132

IN REPLY REFER TO:
1104/ALS:vh
10330
Ser: 1104-16

15 JUN 1971

From: Commander, Naval Undersea Research and Development Center
To: Chief, Division of Materials Licensing, U. S. Atomic Energy Commission, Washington, D. C. 20545
Via: Commander, Naval Facilities Engineering Command, Code 042

Subj: Byproduct Material License 4-13495-1; request for amendment of

Ref: (a) Handbook of Shielding Requirements and Radiation Characteristics of Isotopic Power Sources for Terrestrial, Marine and Space Applications, ORNL-3576
(b) NUC ltr 1104/ALS:vh, 10330, Ser: 1104-9 dtd 3 May 1971

Encl: (1) Sketch of ORNL Sugarman Cask and Fire and Impact Shield (DOT SP-5725)

1. The subject license authorized the shipment of the two SNAP-21 fuel capsules covered by the license in the ORNL Type M shipping cask, (DOT SP-5595) upon completion of the tests. In view of an existing unavailability of the Type M Cask, the ORNL proposes to substitute two ORNL Sugarman Cask and Fire and Impact Shields (DOT SP-7525) for the shipment. A sketch of the Sugarman cask assembly is submitted as enclosure (1). It is noted the allowable thermal loading of the cask is 200 watts. Each of the SNAP-21 capsules has a heat output of 186 watts.

2. Oak Ridge National Laboratory drawings DRD 2329 and DRD 2533 provide more detailed information concerning cask design. Copies of these are being forwarded to you by ORNL.

3. Using reference (a) as a guide, the dose-rates exterior to the shipping cask with the 30,000 curies of strontium-90 contained are expected to be 16 mr/hr at the surface and 1 mr/hr at one meter.

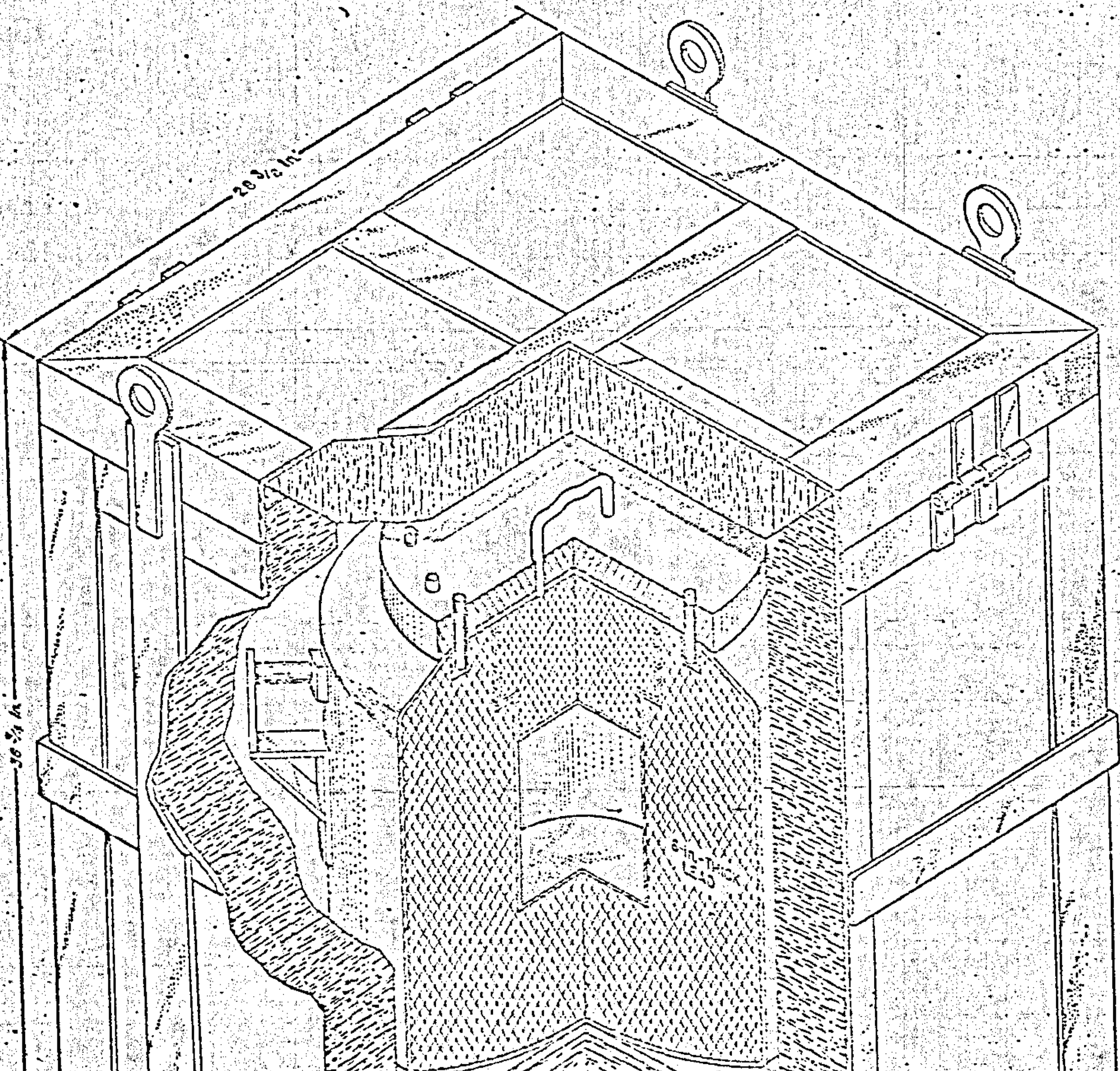
4. This letter, with corrected and additional information will replace and supersede reference (b).

GEORGE W. COULTER
By direction

DOT SP 5725

Shipping wt. 3000 lbs

ORNL-DWG 67-7812

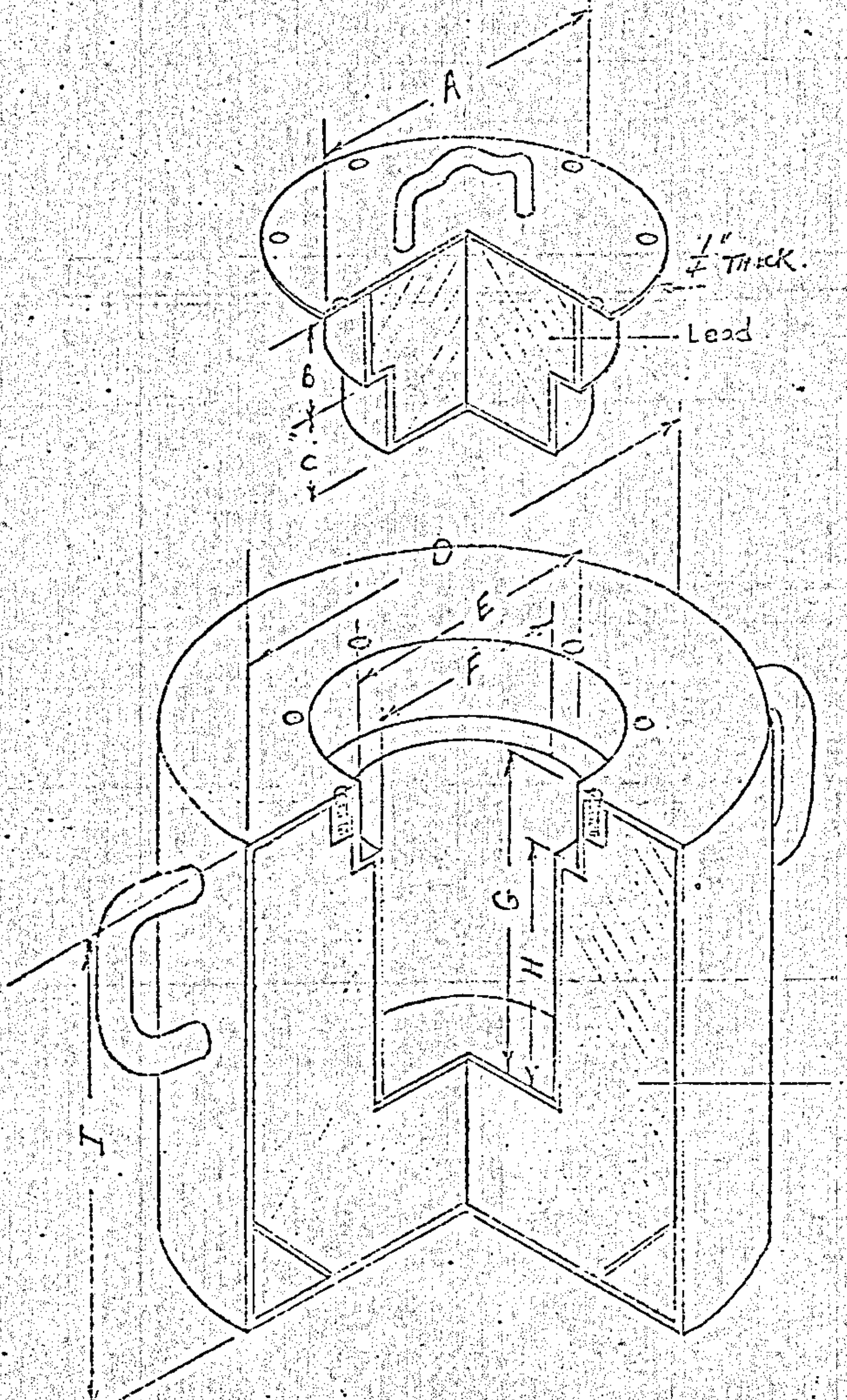


SUGARMAN SHIPPING CASK WITH WOODEN FIRE AND IMPACT SHIELD

Type	A	B	C	D	E	F	G	H	I
[illegible] lb.	11 1/2"	2 1/2"	2 1/2"	17"	8 27/32"	7 3/8"	10"	7 1/2"	14 1/2"
2250 lb.	14 3/4"	4"	2"	20"	9 1/4"	7 1/4"	14 1/2"	10 1/2"	29 3/16"

RETURNABLE CONTAINER FOR SOLID MATERIALS SERIES S-10

O.R.N.L. | 12/18/5? | T.C.W.



1104

DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D. C. 20390

FAC 042
0423B 5100.26
Ser: 232
14 June 1971

Gentlemen:

Reference is made to Naval Undersea Research and Development Center letter 10330 Ser: 1104-9 of 3 May 71 and our letter file 5100.26 Ser: 191 26 May 1971 which requested amendment of Byproduct Material License No. 04-00487-09 for the purpose of using the Sugarman shipping container for the shipment of 30,000 curies of strontium titinate capsules.

The foregoing license number has been changed to 4-13495-1. It is therefore requested that this license be amended to permit the use of the Sugarman cask for the purpose intended.

Sincerely,

R. E. CARLTON

Head, Nuclear Safety Branch
By direction

1104
10330
JD

U. S. Atomic Energy Commission
Division of Materials Licensing
Chief Fuel Fabrication & Transportation Branch
Washington, D. C. 20545
Attn: Mr. Nussbaumer

Copy to:
NURDC (A. L. Smith Code 703)

1104

3 MAY 1971

DEPARTMENT OF THE NAVY
NAVAL UNDERSEA RESEARCH AND DEVELOPMENT CENTER
SAN DIEGO, CALIFORNIA 92132

IN REPLY REFER TO:
1104/ALS:vh
10330
Ser: 1104-9

3 MAY 1971

From: Commander, Naval Undersea Research and Development Center
To: Chief, Division of Materials Licensing, U. S. Atomic Energy Commission, Washington, D. C. 20545
Via: Commander, Naval Facilities Engineering Command, Code 042

Subj: Byproduct Material License 04-00487-09; request for amendment of

Encl: (1) Sketch of ORNL Sugarman Cask and Fire and Impact Shield (DOT SP-5725)

1. The subject license authorized the shipment of the two SNAP-21 fuel capsules covered by the license in the ORNL Type M shipping cask (DOT SP-5595) upon completion of the tests. In view of an existing unavailability of the Type M Cask, the ORNL proposes to substitute two ORNL Sugarman Cask and Fire and Impact Shields (DOT SP-7525) for the shipment. A sketch of the Sugarman cask assembly is submitted as enclosure (1). It is noted the allowable thermal loading of the cask is 200 watts. Each of the SNAP-21 capsules has a heat output of 186 watts.

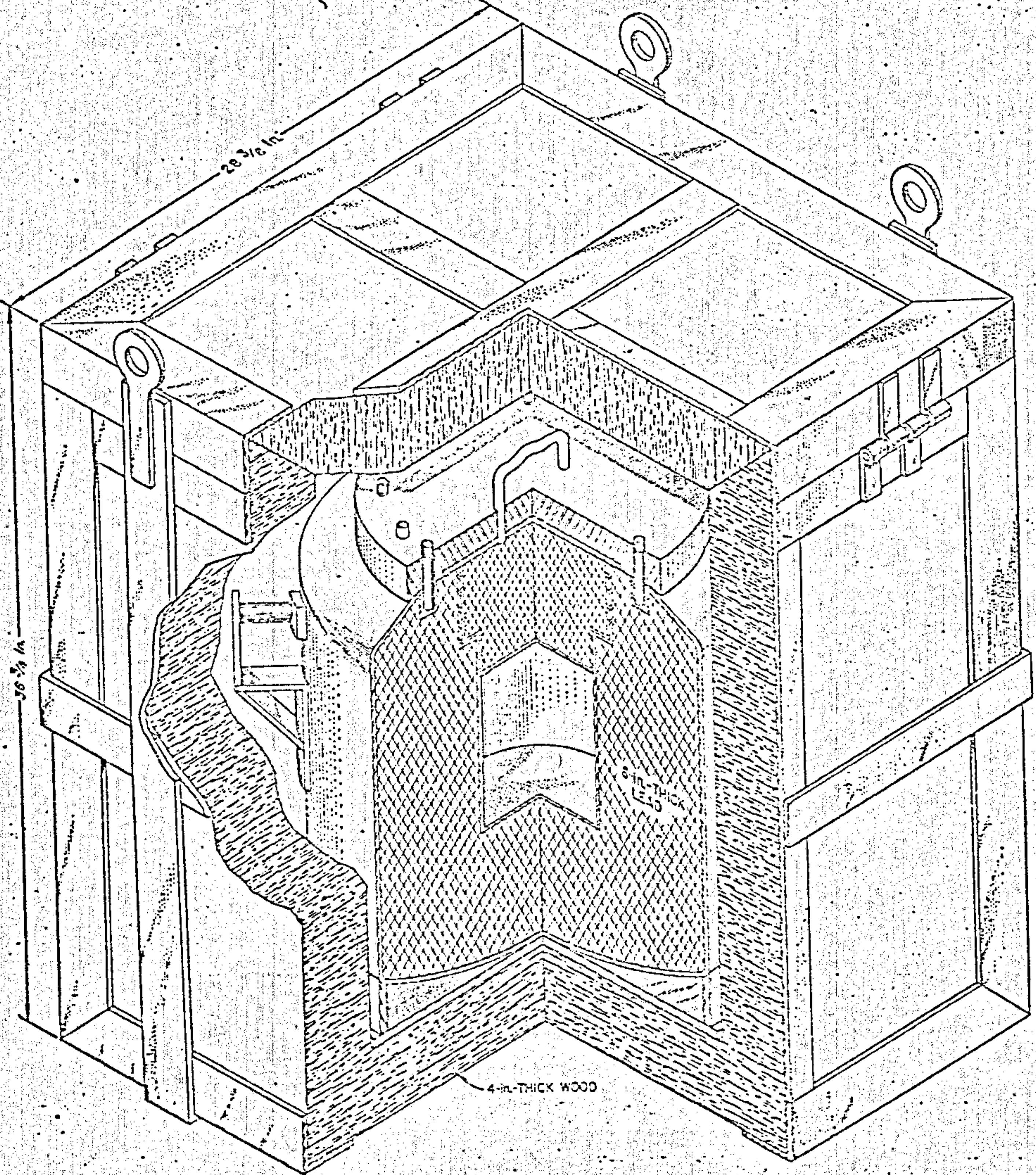
2. It is requested that BPM License 04-00487-09 be amended to permit the use of the Sugarman casks for shipment of the two capsules.

M. E. VEHAR
By direction

DOT SP 5725

Shipping Wt. 3000 lbs

ORNL-DWG 67-7812

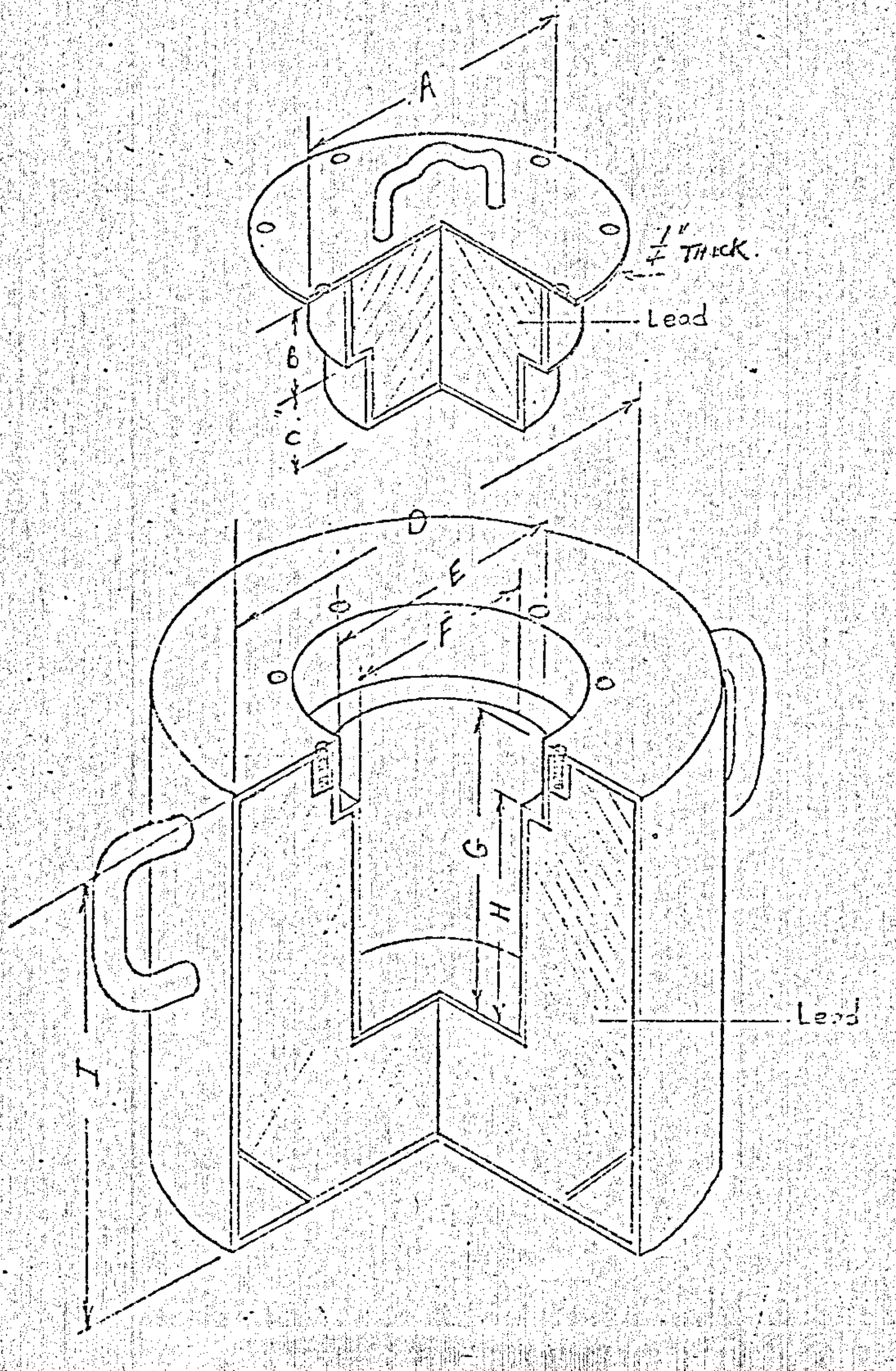


SUGARMAN SHIPPING CASK WITH WOODEN FIRE AND IMPACT SHIELD

RETURNABLE CONTAINER FOR SOLID MATERIALS SERIES S-10

O.R.N.L. 12/18/54 T.C.W.

Type	A	B	C	D	E	F	G	H	I
1400 lb.	11 1/2"	2 1/2"	2 1/2"	17"	8 27/32"	7 3/8"	10"	7 1/2"	14 1/2
2250 lb.	14 1/4"	4"	2"	20"	9 1/4"	7 1/4"	14 1/2	10 1/2"	20 3/16



Form AEC-591
(7/67)

UNITED STATES ATOMIC ENERGY COMMISSION
DIVISION OF COMPLIANCE

INSPECTION FINDINGS AND LICENSEE ACKNOWLEDGMENT

1. LICENSEE Department of the Navy Naval Undersea Research and Development Center San Diego, California 92132	2. REGIONAL OFFICE U. S. Atomic Energy Commission Region V, Division of Compliance 2111 Bancroft Way Berkeley, California 94704
3. LICENSE NUMBER(S) 4-13495-1	4. DATE OF INSPECTION March 10, 1970

5. INSPECTION FINDINGS

☒ A. No item of noncompliance was found.

☐ B. Rooms or areas were not properly posted to indicate the presence of a RADIATION AREA. 10 CFR 20.203(b) or 34.42

☐ C. Rooms or areas were not properly posted to indicate the presence of a HIGH RADIATION AREA. 10 CFR 20.203(c) (1) or 34.42

☐ D. Rooms or areas were not properly posted to indicate the presence of an AIRBORNE RADIOACTIVITY AREA. 10 CFR 20.203(d)

☐ E. Rooms or areas were not properly posted to indicate the presence of RADIOACTIVE MATERIAL. 10 CFR 20.203(e)

☐ F. Containers were not properly labeled to indicate the presence of RADIOACTIVE MATERIAL. 10 CFR 20.203(f) (1) or (f) (2)

☐ G. A current copy of 10 CFR 20, a copy of the license, or a copy of the operating procedures was not properly posted or made available. 10 CFR 20.206(b)

☐ H. Form AEC-3 was not properly posted. 10 CFR 20.206(c)

☐ I. Records of the radiation exposure of individuals were not properly maintained. 10 CFR 20.401(a) or 34.33(b)

☐ J. Records of surveys or disposals were not properly maintained. 10 CFR 20.401(b) or 34.43(d)

☐ K. Records of receipt, transfer, disposal, export or inventory of licensed material were not properly maintained. 10 CFR 30.51, 40.61 or 70.51

☐ L. Records of leak tests were not maintained as prescribed in your license, or 10 CFR 34.25(c)

☐ M. Records of inventories were not maintained. 10 CFR 34.26

☐ N. Utilization logs were not maintained. 10 CFR 34.27

Raymond F. Fish Jr.
(AEC Compliance Inspector)

6. LICENSEE'S ACKNOWLEDGMENT

The AEC Compliance Inspector has explained and I understand the items of noncompliance listed above. The items of noncompliance will be corrected within the next 30 days.

(Date) (Licensee Representative — Title or Position)

ORIGINAL: LICENSEE. COPIES: ☐ CO REGION ☐ CO HEADQUARTERS ☐ CO ENFORCEMENT

ROUTE SLIP AND OFFICE MEMO
NAVELEX-5216/1 (Rev. 8-66)

DO NOT DETACH FROM OFFICIAL CORRESPONDENCE.
WRITE OR PRINT LEGIBLY IN INK.

CONTROL NO.	REPLY DUE BY			
1205-030-69				
ORIGINATOR (Code, and Extension when applicable)	SERIAL	DATE	SUBJECT CLASS.	CROSS REF.
		12/2/69	9900	

SUBJECT

ENCLOSURE

ROUTE TO CODE	SYMBOL	RELEASED INITIAL	DATE MON.	DAY	YEAR	
C						SIGNATURE, EXT. CODE AND DATE ARE TO FOLLOW COMMENTS. SYMBOLS: A - Action, C - Comment, I - Information, P - Prepare Reply, R - Retain Copy
0516						

FILE - UNLESS THIS MATERIAL IS TO BE FURTHER ROUTED RETURN TO FILE BY DATING AND INITIALING.

INITIAL	DATE

D05167

SAN FRANCISCO BAY NAVAL SHIPYARD
SAN FRANCISCO, CALIFORNIA 94135

IN REPLY REFER TO:
R200-26
8071

DEC -2 1969

From: Commander, San Francisco Bay Naval Shipyard
To: Chief, Division of Material Licensing,
U.S. Atomic Energy Commission
Via: Commander, Naval Electronic Systems Command (ELEX 05163)

Subj: Termination of AEC Biproduct Material License held by NRDL

Encl: (1) Transfer of NRDL Biproduct Material License

1. Following the disestablishment of NRDL on 3 November 1969 all remaining functions were transferred to the NRDL Disestablishment Group, San Francisco Bay Naval Shipyard, San Francisco, California. Byproduct Material License 04-00487-09 issued to NRDL for 66,000 curies of strontium 90 was retained in the transfer.

2. On 1 December 1969 two SNAP-21 fuel capsules of approximately 30,000 curies each were transferred from NRDL Byproduct Material License No. 04-00487-09 to NUC Biproduct Material License No. 4-13495-1 (see enclosure (1)). This was an on-site transfer of material located at Marine Environment Test Station, San Clemente Island, California.

4. This activity no longer possesses any strontium 90. It is requested that NRDL Biproduct License No. 04-00487-09 be terminated at this time.

M.M. EDWARDS, JR
Officer-in-Charge
NRDL Disestablishment Group
By direction.

ACTION; 0516
INFO:
FILE NO: 9900
CON. NO: 1205 030 -69

SAN FRANCISCO BAY NAVAL SHIPYARD
SAN FRANCISCO, CALIFORNIA 94135

IN REPLY REFER TO:
R200-26
8071

DEC -2 1969

From: Commander, San Francisco Bay Naval Shipyard
To: Chief, Division of Material Licensing,
U.S. Atomic Energy Commission
Via: Commander, Naval Electronic Systems Command (ELEX 05163)

Subj: Termination of AEC Biproduct Material License held by NRDL

Encl: (1) Transfer of NRDL Biproduct Material License

1. Following the disestablishment of NRDL on 3 November 1969 all remaining functions were transferred to the NRDL Disestablishment Group, San Francisco Bay Naval Shipyard, San Francisco, California. Byproduct Material License 04-00487-09 issued to NRDL for 66,000 curies of strontium 90 was retained in the transfer.

2. On 1 December 1969 two SNAP-21 fuel capsules of approximately 30,000 curies each were transferred from NRDL Byproduct Material License No. 04-00487-09 to NUC Biproduct Material License No. 4-13495-1 (see enclosure (1)). This was an on-site transfer of material located at Marine Environment Test Station, San Clemente Island, California.

4. This activity no longer possesses any strontium 90. It is requested that NRDL Biproduct License No. 04-00487-09 be terminated at this time.

M.M. EDWARDS, JR
Officer-in-Charge
NRDL Disestablishment Group
By direction.

U. S. GOVERNMENT PRINTING OFFICE: 1967 — 242-653

SHIPPING CONTAINER TALLY → 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50

REQUISITION AND INVOICE/SHIPPING DOCUMENT

SHEET NO.: 1 | NO. OF SHEETS: 1 | 5. REQUISITION DATE: 1 Dec 1969 | 6. REQUISITION NUMBER: 62479- LSD-90467/69

1. FROM: NAVAL RADIOLOGICAL DEFENSE LABORATORY (CODE 252)
SAN FRANCISCO, CALIFORNIA 94135

2. TO:

7. DATE MATERIAL ~~XXXXXX~~ Transferred: 1 Dec. 1969

8. PRIORITY:

9. AUTHORITY OR PURPOSE: Disestablishment of NRDL/Kielwasser

10. SIGNATURE: Head, Logistic Support Division

11a. VOUCHER NUMBER AND DATE:

b.

12. DATE ~~SHIPPED~~ Transferred: 1 Dec. 1969

13. MODE OF SHIPMENT:

14. BILL OF LADING NUMBER:

15. AIR MOVEMENT DESIGNATOR OR PORT REFERENCE NO.:

3. SHIP TO - MARK FOR:
COMMANDER
NAVAL UNDERSEA RESEARCH AND DEVELOPMENT CENTER
SAN DIEGO, CALIFORNIA 92132

4. APPROPRIATION AND SUBHEAD	OBJ. CL.	BUR. CONT. NO.	SUBAL-LOT.	AUTHORIZATION ACCT'G ACTIVITY	TRANS. TYPE	PROPERTY ACCT'G ACTIVITY	COUNTRY	COST CODE	AMOUNT

ITEM NO. (a)	FEDERAL STOCK NUMBER, DESCRIPTION, AND CODING OF MATERIAL AND/OR SERVICES (b)	UNIT OF ISSUE (c)	QUANTITY REQUESTED (d)	SUPPLY ACTION (e)	TYPE CONTAINER (f)	CONTAINER NOS. (g)	UNIT PRICE (h)	TOTAL COST (i)
1	Strontium titanate encapsulated as SNAP-21 fuel capsules. Approx. 30,000 Curies each. Nos. 2 & 3. (SR 90)	ea	2					

NOTE: Transferred from NRDL Byproduct Material License No. 04-00487-09 to NUC Byproduct Materail License No. 4-13495-1. On-site transfer. Material at Marine Environment Test Station, San Clemente Island, Calif.

It is requested that the 1, 2 and 3 copies of this Invoice be properly signed to indicate receipt of this material and returned to:
U. S. Naval Radiological Defense Laboratory
Code 250
San Francisco 24, California

RECEIPT OF MATERIAL LISTED HEREON ACKNOWLEDGED:

(Signature and Title) (Date)

16. TRANSPORTATION VIA MATS OR MSTS CHARGEABLE TO

17. SPECIAL HANDLING

18. RECAPITULATION OF SHIPMENT	TOTAL CONTAINER	TYPE CONTAINER	DESCRIPTION	TOTAL WEIGHT	TOTAL CUBE
ISSUED BY					
CHECKED BY					
PACKED BY					
	← TOTAL →				

19. RECEIPT	DATE	BY	
CONTAINERS RECEIVED EXCEPT AS NOTED			SHEET TOTAL
QUANTITIES RECEIVED EXCEPT AS NOTED			GRAND TOTAL
POSTED			20. RECEIVER'S VOUCHER NO.

51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

ENCLOSURE (1)

DD FORM 1 MAR 69 1149 (9-PT) REPLACES EDITION OF 1 MAY 68 WHICH MAY BE USED

STOCK NO. 0101-804-9010

ORIGINAL

FORM AEC-374A
(2-65)

U. S. ATOMIC ENERGY COMMISSION
BYPRODUCT MATERIAL LICENSE
Supplementary Sheet

License Number 4-487-9
Amendment No. 3

Rec'd. 11/5/69

Commander, Naval Electronic
Systems Command (Code 05163)
Munitions Building
18th and Constitution Avenue, NW.
Washington, D. C. 20390

In accordance with telcon between Mr. L. Miller & GNM a copy of this Amend #3 was fwded to the *NROL Desealablish Group on 11/6/69

Attention: Mr. M. G. Williams

Gentlemen:

Pursuant to an application transmitted through the Naval Facilities Engineering Command (T. F. Jones, FAC 042 5100.26 Ser: 442) dated October 30, 1969, AEC Byproduct License No. 4-487-9 is hereby terminated. A new license has been issued to the Department of the Navy, Naval Undersea Research and Development Center, San Diego, California (AEC Byproduct License No. 4-13495-1), to cover the activities previously authorized by this license.

* Autovon - 8-799-2862

Date NOV 3 1969

For the U. S. Atomic Energy Commission

by Chief, Irradiated Fuels Branch
Division of Materials Licensing
Washington, D. C. 20545

BYPRODUCT MATERIAL LICENSE

Supplementary Sheet

License Number 4-487-9
Amendment No. 2

Recd: Su 05163 on 12/16/68 —
fwded by Rubber Stamp.
Forms to USNRDL on 12/16/68

Commander, Naval Electronic
Systems Command (Code 05163)
Munitions Building
18th and Constitution Avenue, NW.
Washington, D.C. 20390

Attention: Mr. H. C. Williams

Gentlemen:

Pursuant to your request in letter 9900 Ser 354-0516, dated November 26, 1968, License No. 4-487-9 is amended as follows:

Conditions 9 and 10 are amended by adding:

9. In addition, the licensee may perform tests on the seaward end of the pier of North Light Harbor Pier at San Clemente Island.

10. Letter dated November 26, 1968.

For the U. S. Atomic Energy Commission

Original signed by
R. B. Chitwood

Date DEC 9 1968

by Chief, Irradiated Fuels Branch
Division of Materials Licensing
Washington, D. C. 20545

5.

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

License No. 04-00487-09 Amendment No. 1 (71-1)

LICENSE

Pursuant to the Atomic Energy Act of 1954, as amended, and Title 10, Code of Federal Regulations, Chapter 1, Part 30 "Rules of General Applicability of Licensing of Byproduct Material", Part 40 "Licensing of Source Material", and Part 71 "Packaging of Radioactive Material for Transport", and in reliance on statements and representations heretofore made by the licensee, a license is hereby issued authorizing the licensee to receive, possess, use, and transfer the byproduct and source material described below for the purpose designated below, in accordance with the regulations in said parts and the conditions set forth below. This license shall be deemed subject to the conditions specified in Section 183 of the Atomic Energy Act of 1954, as amended, and to all applicable rules, regulations, and orders of the Atomic Energy Commission now or hereafter in effect.

1. Licensee:

   Department of the Navy
   U. S. Naval Radiological Defense Laboratory
   San Francisco Bay Naval Shipyard
   San Francisco, California 94135

2. Purpose:

   A. Storage of the material specified in Item 3 of this license in the shipping cask specified in Item 4 of this license at the licensee's facility, San Francisco Bay Naval Shipyard, San Francisco, California, and delivery of the cask to a carrier for transport.

   B. Loading of the material specified in Item 3 of this license in the shipping cask specified in Item 4 of this license at the licensee's facility at San Clemente Island off the coast of California, and delivery of the cask to a carrier for transport.

3. Byproduct and Source Material:

   A. Uranium used as shielding constituting part of the shipping cask specified in Item 4 of this license.

   B. Not more than two (2) SNAP-21 fuel capsules each containing not more than 33,000 curies of strontium 90.

4. Packaging:

   Oak Ridge National Laboratory Uranium Shielded Cask, Model M.

5. Fuel capsules which have been exposed to an ocean environment shall be contained within the inner container described in enclosure 1 of the application supplement dated August 8, 1968, in addition to the packaging specified in Item 4 of of this license.

6. The transportation of AEC licensed material shall be subject to all applicable regulations of the Department of Transportation and other agencies of the United States having jurisdiction.

   When Department of Transportation regulations or regulations of other agencies of the United States having jurisdiction are not applicable to the transportation of AEC licensed material, the licensee shall comply with all applicable requirements of the rules and regulations, as amended, appropriate to the mode of transport, of the Department of Transportation (41 CFR Parts 171-178), Federal Aviation Agency (14 CFR Part 103), and Coast Guard (46 CFR Part 146) insofar as such rules and regulations relate to the packaging of the licensed material and to the marking and labeling of the package and placarding of the transporting vehicle and accident reporting to the same extent as if the transportation were in interstate or foreign commerce. Any requests for notifications or exceptions to those requirements, and any modifications referred to in those requirements shall be filed with, or made to, the Atomic Energy Commission.

7. Expiration Date: September 30, 1971.

REFERENCES

Licensee's application dated December 13, 1967, and supplements on March 7, May 6, and August 8, 1968.

FOR THE ATOMIC ENERGY COMMISSION
Original Signed by
Lyall Johnson

for R. B. Chitwood, Chief
Irradiated Fuels Branch
Division of Materials Licensing

Date of Issuance: SEP 26 1968

FORM AEC-374 (7-66) 10 CFR 30

U. S. ATOMIC ENERGY COMMISSION

BYPRODUCT MATERIAL LICENSE

Pursuant to the Atomic Energy Act of 1954 and Title 10, Code of Federal Regulations, Chapter 1, Parts 30, 32, 33, 34, and 35, and in reliance on statements and representations heretofore made by the licensee, a license is hereby issued authorizing the licensee to receive, acquire, own, possess, transfer and import byproduct material listed below; and to use such byproduct material for the purpose(s) and at the place(s) designated below. This license shall be deemed to contain the conditions specified in Section 183 of the Atomic Energy Act of 1954, and is subject to all applicable rules, regulations, and orders of the Atomic Energy Commission now or hereafter in effect and to any conditions specified below.

Licensee

1. Department of the Navy

2. U.S. Naval Radiological Defense Laboratory
San Francisco Bay Naval Shipyard
San Francisco, California 94135

Rec'd: on 9/30/68 from AEC - fwded to Lab. by Stamp Form on 9/30/68

3. License number 04-00487-09

4. Expiration date September 30, 1971

5. Reference No.

6. Byproduct material (element and mass number)	7. Chemical and/or physical form	8. Maximum amount of radioactivity which licensee may possess at any one time
Strontium 90.	Strontium titanate encapsulated and contained as SNAP-21 fuel capsules.	A total of 66,000 curies in two (2) fuel capsules (each capsule containing 33,000 curies).

9. The licensee is hereby authorized to expose two SNAP-21 fuel capsules to an ocean environment in the presence of the capsules' normal high intensity radiation field. The ocean environment test shall be conducted at an underwater location adjacent to San Clemente Island off the coast of California.

10. Except as specifically provided otherwise by this license, the licensee shall possess and use the byproduct material described in Items 6, 7, and 8 of this license in accordance with the statements, representations, and procedures contained in the application dated December 13, 1967, and supplemented on March 7, May 6, and August 8, 1968.

11. The licensee shall comply with the provisions of Title 10, Code of Federal Regulations, Part 20 "Standards for Protection Against Radiation", with the following modifications:

A. The licensee is authorized to discharge water containing up to 1×10^{-4} µCi/cc from the exposure shield chamber during the ocean implantation.

B. Pursuant to Paragraph 20.103(c)(3), the licensee is authorized to make allowance for protective clothing and equipment in accordance with the application supplement dated August 8, 1968.

12. All procedures affecting the health and safety of the activities authorized by this license shall be reviewed and approved prior to the initiation of activities by the Radiological Safety Committee of the U.S. Naval Radiological Defense Laboratory (AEC Byproduct Material License No. 04-00487-03).

For the U. S. Atomic Energy Commission
Original Signed by
Lyall Johnson

Date SEP 2 6 1968

for by Chief, Irradiated Fuels Branch
Division of Materials Licensing
Washington, D. C. 20545

Addressee

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

SEP 26 1968

Commander, Naval Electronic
Systems Command (Code 05163)
Munitions Building
18th & Constitution Avenue
Washington, D.C. 20390

Attention: Mr. M. G. Williams

Gentlemen:

Enclosed is AEC License No. 04-00487-09 and Amendment No. 1 (71-1), authorizing the exposure of two SNAP-21 fuel capsules to an ocean environment at an underwater location adjacent to San Clemente Island off the coast of California and the delivery of the capsules to a carrier for transport in the ORNL Uranium Shielded Cask, Model M. Based on the drawing numbers of the cask design you submitted, we believe the Model M Cask is the same cask which you designated as the ORNL Cask No. ARD-2499. The cask designation was discussed with your Messrs. A. Smith and F. Fong during a telecon on August 21, 1968.

Please note that Amendment No. 1 (71-1) does not authorize the transport of AEC licensed material subject to regulation by the Department of Transportation (DOT). Questions regarding their requirements should be directed to DOT. Transport of licensed material not subject to DOT regulations is authorized by this amendment.

Sincerely,

R. B. Chitwood

R. B. Chitwood, Chief
Irradiated Fuels Branch
Division of Materials Licensing

Enclosures:
1. License No. 04-00487-09
2. Amendment No. 1 (71-1)

cc: Mr. William A. Brobst, DOT, w/encl. No. 2.

ACTION: 05163
INFO:
FILE NO: 9670
CON. NO: 0927-127-68

LS

Lic #04-00487-09, with Amend #1 dtd. 9/26/68 issued by AEC

325 - 0410

(A)
ELFX ltr 385-0560, dtd 13 Dec 1967 - 1st End on Aeve
NRDL ltr of 7 Dec 1967
request to amend Lab's Lic for possession & use of 60,000 Ci of ^{90}Sr in (2) sealed SNAP-21 capsules to be subjected to ocean exposure studies
1. Mtls - concerned info relevant to shipping cask for sources and test plan to be used by the Lab in performing studies"
2. Test plan
Then ltr from Lab requesting

(B) ELFX ltr ser 52-0516, dtd 7 Mar '68 - 1st End on LAB's ltr 730-239, dtd 26 Feb 1968
A request to replace procedure when xferring SNAP capsules containing 30,000 of ^{90}Sr ^{90}Y from shipping casks to exp. chamber

(C) ELFX ltr ser 192-0576, dtd 8 Aug 68 - Lab ltr ser 730-413 of 1 Aug 68 - Clarifies mtl acquisition reasons by Mtl submitted to AEC - Environmental (Testing of SNAP 21 fuel Cap. @ San Clemente

Jan 5.

Re-license with the AEC

SNAP-21 Isotope Gen Thermo-electric

App. 13 Dec. 1967
Supplements 7 Mar. 1968
6 May 1968
8 Aug 1968

Report from 3-M company (*)

Ltr - 3-M =
MMM- 3691-33

App simply enclosed report

Zerocopy of ltr.

Tied-in to NRDL =

ϕ 2 –
x Program Phase IV Dep
Sea Radioisotope Fueled
Thermoelectric Gen Pwr
Supply Sys - Pre Safety Analysis

NRDL - proposed a test system

Environmental
San Clemente
Under Naval Ordnance Test
Station

12-9-74

Grace Hendricks:
Directory of Radiac Eqpt.
NAVSHIPS 94200.5-2 1969??

Mr. Young:-

CFR 19.11 =

96372A
3A

Notice:-
Chasno want it.

12-9-74

Distribution List (cont'd) (13)

USS Fulton (AS-11)
Sperry (AS-12)
Gilmore (AS-16)
Orion (AS-18)
Proteus (AS-19)
Hunley (AS-31)
Holland (AS-32)
Simon Lake (AS-33)
Canopus (AS-34)
L.Y. Spear (AS-36)
Dixon (AS-37)
Samuel Gompers (AD-37)
Puget Sound (AD-38)

11-25-69

Telconto: Louis Miller*
8-799-2478*

1. All material except ≈5# of waste has been xferred &/or disposed of as waste.
2. More than 80% or more to waste.
Under ≈ 1# xferred to SRI
" ≈ 1# " to Stanford
" ≈ 1# " to NOL
The remaining 5# will be disposed of as waste.

Signed By

[Issued to USNRDL] [Don Harmon]

[SMB-396 - re-newed 21 July 1967 - exp-dt 31 July 1972]

8.9%

(1) NATURAL URANIUM — 50#s Any Chem or Phy. Form

(2) URANIUM Depleted
In ^{235}U Isotope — 500#s " " " " 87.9%

(3) Thorium (Isotopes) — 10#s " " " " 1.48

Total 560#s

Used as follows:-

(1) Cal. Stds; Ion Exchge Studies; Neut Act. Analysis; Fission Prod. Production (in μgm up to gram amounts)

(2) Std. sources; Fission fragment track production; radiochemistry & Neut Act Analysis.
(in μgm to gram amounts)

(3) Fission fragment track production; radiochemistry; Neut Act Analysis

Used in basic & applied research on the physical, chemical, & biological effects of nuclear & thermal radiation, with particular emphases upon those factors relating to the requirements of the military services.

Other activities 25 November 1969

2478

8-799-2862 [Call To: Louis Miller]

3068

2743

Eugene Toschlini Retire (Paul Zigler Setting Up Op)
Louis Miller - Did not retire.
Al. Kielwasser Retire -
Geo. Hitchcock Retire
Art. Redmond Retire

NOC - Thorium - 80 % or more to Waste.

SRI. - Under #1#

Stanford Under 1#

5# To Waste

703

DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D. C. 20390

FAC 042
5100.26
Ser: 455

19 NOV 1969

70 | 703 | 70

From: Commander, Naval Facilities Engineering Command
To: Commander, Naval Undersea Research and Development Center, San Diego

Subj: SNAP-21 Test Program; AEC license for

Ref: (a) NAVUSEARANDCEN ltr 703/ALS:lvp 10330 Ser 70-66 to USAEC via NAVFAC of 24 Oct 1969
(b) NAVFAC ltr FAC 042 5100.26 Ser 442 to USAEC of 30 Oct 1969

Encl: (1) AEC Byproduct Material License No. 4-13495-1 and Amendment No. 1 (71-1)
(2) NAVFAC Radiological Safety Guide To: 703
(3) Six (6) copies, Form NAVFAC 9-11310/5 (7-69) "Request for Safety Review" To: 703

1. In response to reference (a), endorsed by reference (b), the U. S. Atomic Energy Commission has issued the subject license, which is forwarded as enclosure (1) for use and retention.

2. Attention is directed to item (14) of enclosure (1) which is imposed only as an interim measure until such time that a radiological safety committee is established by the addressee. The referenced guide and appropriate forms are forwarded as enclosures (2) and (3) to enable compliance with the license.

?

Thomas F. Jones

T. F. Jones
Regulatory Staff Head
By direction

Have talked to F. Kawahara about this. He is working up a revised test plan. This will be submitted to the NAVFAC Committee for approval.

It appears that our own Committee is a requirement for the near future. I will specify such a committee when I write our Rad Safety Control Manual. I'll discuss the composition of the Committee with you.

AZG

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UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

OCT 31 1969

Naval Facilities Engineering Command
P. O. Box 610
Falls Church, Virginia 22046

Attention: Mr. T. F. Jones

Gentlemen:

Enclosed are AEC Byproduct License No. 4-13495-1 and Amendment No. 1 (71-1) issued in response to your application dated October 30, 1969 (FAC 042 5100.26 Ser:442).

You will note that this license refers to submissions made by the Naval Radiological Defense Laboratory in connection with its application, and does not reflect AEC approval of the details submitted in your application. We have issued the license in this fashion in view of the limited time since receipt of your application on October 30 and the necessity of maintaining a valid license in effect with respect to the byproduct material being used by the Navy. We will review the details of your application in the near future.

Sincerely,

R. B. Chitwood

R. B. Chitwood, Chief
Irradiated Fuels Branch
Division of Materials Licensing

Enclosures:
1. License No. 4-13495-1
2. Amendment No. 1 (71-1) to License No. 4-13495-1

cc w/encl No. 2
Mr. William A. Brobst, DOT

ENCLOSURE 1

FORM AEC-374
(7-66)
10 CFR 30

U. S. ATOMIC ENERGY COMMISSION

BYPRODUCT MATERIAL LICENSE

Pursuant to the Atomic Energy Act of 1954 and Title 10, Code of Federal Regulations, Chapter 1, Parts 30, 32, 33, 34, and 35, and in reliance on statements and representations heretofore made by the licensee, a license is hereby issued authorizing the licensee to receive, acquire, own, possess, transfer and import byproduct material listed below; and to use such byproduct material for the purpose(s) and at the place(s) designated below. This license shall be deemed to contain the conditions specified in Section 183 of the Atomic Energy Act of 1954, and is subject to all applicable rules, regulations, and orders of the Atomic Energy Commission now or hereafter in effect and to any conditions specified below.

Licensee

1. Department of the Navy
Naval Undersea Research and
Development Center
2. San Diego, California 92132

3. License number 4-13495-1

4. Expiration date September 30, 1971

5. Reference No.

6. Byproduct material (element and mass number)	7. Chemical and/or physical form	8. Maximum amount of radioactivity which licensee may possess at any one time
Strontium 90.	Strontium titanate encapsulated and contained as SNAP-21 fuel capsules.	A total of 66,000 curies in two (2) fuel capsules (each capsule containing 33,000 curies).

9. The licensee is hereby authorized to expose two SNAP-21 fuel capsules to an ocean environment in the presence of the capsules' normal high intensity radiation field. The ocean environment test shall be conducted at an underwater location adjacent to San Clemente Island off the coast of California. In addition, the licensee may perform tests on the seaward end of the pier of North Light Harbor Pier at San Clemente Island.

10. Except as specifically provided otherwise by this license, the licensee shall possess and use the byproduct material described in Items 6, 7, and 8 of this license in accordance with the statements, representations, and procedures contained in the application dated December 13, 1967 (9900 Ser 835-0516), as supplemented on:

    A. March 7, 1968 (9900 Ser 52-0516)
    B. May 6, 1968 (9900 Ser 105-0516)
    C. August 8, 1968 (9900 Ser 192-195)
    D. November 26, 1968 (9900 Ser 354-0516)

11. The licensee shall comply with the provisions of Title 10, Code of Federal Regulations, Part 20 "Standards for Protection Against Radiation," with the following

License Number 4-13495-1

modifications:

A. The licensee is authorized to discharge water containing up to 1×10^{-4} µCi/cc from the exposure shield chamber during the ocean implantation.

B. Pursuant to Paragraph 20.103(c)(3), the licensee is authorized to make allowance for protective clothing and equipment in accordance with the application supplement dated August 8, 1968 (9900 Ser 192-195).

12. Individual User(s):

A. F. K. Kawahara

13. Radiation Protection Officer:

A. A. L. Smith

B. W. W. MacKenzie, Alternate

14. All procedures affecting the health and safety of the activities authorized by this license shall be reviewed and approved prior to the initiation of activities in the manner specified in Naval Facilities Engineering Safety Guide submitted with application dated October 22, 1969 (FAC 042 5100.16 Ser: 433).

For the U. S. Atomic Energy Commission

Date OCT 3 1 1969

by Chief, Irradiated Fuels Branch

Division of Materials Licensing
Washington, D. C. 20545

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

License No. 4-13495-1 Amendment No. 1 (71-1)

LICENSE AMENDMENT

Pursuant to the Atomic Energy Act of 1954, as amended, and Title 10, Code of Federal Regulations, Chapter 1, Part 30 "Rules of General Applicability to Licensing of Byproduct Material", Part 40 "Licensing of Source Material", and Part 71 "Packaging of Radioactive Material for Transport", and in reliance on statements and representations heretofore made by the licensee, a license is hereby issued authorizing the licensee to receive, possess, use, and transfer the byproduct and source material described below for the purpose designated below, in accordance with the regulations in said parts and the conditions set forth below. This license shall be deemed subject to the conditions specified in Section 183 of the Atomic Energy Act of 1954, as amended, and to all applicable rules, regulations, and orders of the Atomic Energy Commission now or hereafter in effect.

1. Licensee:

   Department of the Navy
   Naval Undersea Research and Development
   Center
   San Diego, California 92132

2. Purpose:

   A. Loading of the material specified in Item 3 of this license in the shipping cask specified in Item 4 of this license at the licensee's facility at San Clemente Island off the coast of California, and delivery of the cask to a carrier for transport.

3. Byproduct and Source Material:

   A. Uranium used as shielding constituting part of the shipping cask specified in Item 4 of this license.

   B. Not more than two (2) SNAP-21 fuel capsules each containing not more than 33,000 curies of strontium 90.

4. Packaging:

   Oak Ridge National Laboratory Uranium Shielded Cask, Model M.

5. Fuel capsules which have been exposed to an ocean environment shall be contained within the inner container described in enclosure 1 of the application supplement dated August 8, 1968 (9900 Ser:192-0516), in addition to the packaging specified in Item 4 of this license.

6. The transportation of AEC-licensed material shall be subject to all applicable regulations of the Department of Transportation and other agencies of the United States having jurisdiction.

   When Department of Transportation regulations in 49 CFR Parts 173 - 179 are not applicable to shipments by land of AEC-licensed material by reason of the fact that the transportation does not occur in interstate or foreign commerce, (1) the transportation shall be in accordance with the requirements relating to packaging of radioactive material, marking and labeling of the package, placarding of the transportation vehicle, and accident reporting set forth in the regulations of the Department of Transportation in §§ 173.389 - 173.399, 173.402, 173.414, 173.427, 49 CFR Part 173, "Shippers," and §§ 177.823, 177.842, 177.843, 177.861, 49 CFR Part 177, "Regulations Applying to Shipments Made By Way of Common, Contract, or Private Carriers by Public Highways," and (2) any requests for modifications or exceptions to those requirements, and any notifications referred to in those requirements shall be filed with, or made to, the Atomic Energy Commission.

7. Expiration Date: September 30, 1971.

REFERENCES

Licensee's application dated December 13, 1967, and supplements on March 7, May 6, and August 8, 1968.

FOR THE ATOMIC ENERGY COMMISSION

R B Chitwood

R. B. Chitwood, Chief
Irradiated Fuels Branch
Division of Materials Licensing

Date of Issuance: OCT 3 1 1969

9900
Ser 312 - 0516
7 NOV 1969

From: Commander, Naval Electronic Systems Command
To: Commanding Officer
Naval Radiological Defense Laboratory
San Francisco, California 94135
Attn: Disestablishment Group
Commander Edwards

Subj: AEC Byproduct Material License No. 04-00487-09

Ref: (a) FONECON between Mr. Mahaffey, NAVELEX HQ and Mr. L. Miller, NRDL Disestablishment Group on 6 NOV 1969

Encl: (1) Amendment No. 3 for AEC License dated 3 November 1969

1. Enclosure (1) is an amendment relevant to the termination of subject license and is forwarded for information and retention as discussed during the telephone conversation of reference (a).

Copy to:
BUMED(Code 74)

M. C. WILLIAMS
By direction

MAHAFFEY/mitchell
61457 - 11/7/69

U. S. ATOMIC ENERGY COMMISSION

BYPRODUCT MATERIAL LICENSE

Supplementary Sheet

License Number 4-487-9
Amendment No. 3

Rcd. 11/5/69

Commander, Naval Electronic
Systems Command (Code 05163)
Munitions Building
18th and Constitution Avenue, NW.
Washington, D. C. 20390

In accordance with telecon between Mr. L. Miller & GNM — a copy of this Amend #3 was fwded to the NRDL Disestablishment Group on 11/7/69

Attention: Mr. M. G. Williams

Gentlemen:

Pursuant to an application transmitted through the Naval Facilities Engineering Command (T. F. Jones, FAC 042 5100.26 Ser: 442) dated October 30, 1969, AEC Byproduct License No. 4-487-9 is hereby terminated. A new license has been issued to the Department of the Navy, Naval Undersea Research and Development Center, San Diego, California (AEC Byproduct License No. 4-13495-1), to cover the activities previously authorized by this license.

* Autovon - 8-799-2862

For the U. S. Atomic Energy Commission

by Chief, Irradiated Fuels Branch
Division of Materials Licensing
Washington, D. C. 20545

Date NOV 3 1969

10

DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D. C. 20390

70 | A
703 |

FAC 042
5100.26
Ser: 442
30 OCT 1969

Gentlemen:

We endorse the attached application for a By-Product Material License at the Naval Undersea Research and Development Center, San Diego, California, and request that a license be issued.

Sincerely,

T. F. Jones
Regulatory Staff Head
By direction

U. S. Atomic Energy Commission
Division of Materials Licensing
Washington, D. C. 20545

Attachment:
NURDC San Diego ltr 703/ALS:lvp 10330
Ser 70-66 of 24 Oct 1969

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6503
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10330

Copy to:
NURDC (LCDR W. W. Mackenzie)

DEPARTMENT OF THE NAVY
NAVAL UNDERSEA RESEARCH AND DEVELOPMENT CENTER
SAN DIEGO, CALIFORNIA 92132

IN REPLY REFER TO:
703/ALS:lvp
10330
Ser 70-66
OCT 24 1969

From: Commander, Naval Undersea Research and Development Center
To: Chief, Division of Materials Licensing
U.S. Atomic Energy Commission
Washington, D.C. 20545
Via: Commander, Naval Facilities Engineering Command (Code 042)
P.O. Box 610, Falls Church, Virginia 22046

Subj: By-product material license; request for

Encl: (1) Form AEC-313 with Supplements 1 thru 5 (3 copies)
(2) Additional Information Concerning the SNAP-21 Fuel Capsule Environmental Test Program (3 copies)

1. In December 1968 NRDL (Naval Radiological Defense Laboratory) began marine environmental tests of two SNAP-21 fuel capsules, each containing 30,000 curies of Strontium-90 as the titanate, at San Clemente Island. The test program was sponsored by the Division of Reactor Development and Technology, AEC, and was conducted under NRDL's By-product License OY-00487-09. This test program will be transferred to NUC (Naval Undersea Research and Development Center) upon the disestablishment of NRDL on 3 November 1969.

2. In order to effect transfer of the program, enclosure (1) is submitted for a license for the possession and use of the by-product material. Personnel familiar with the program and equipment necessary to handle the materials and conduct a rad-safety program are being transferred from NRDL to NUC. It is noted that no untoward incident has occurred in the test program to date.

3. In the application for BPM License, certain additional information was submitted by NRDL in answer to specific questions by the DML. This additional information is submitted in support of this application as enclosure (2).

4. It is requested that this license include those special conditions of BPM 04-0487-09 relating to permissable limits for discharge of water, authorization to make allowance for protective equipment, authorization to use the same shipping cask and authorization to perform tests on the pier at North Light Harbor, San Clemente Island Facility.

W. W. MACKENZIE
LCDR, USN
By direction of the Commander

Form AEC-313 (5-58)	ATOMIC ENERGY COMMISSION **APPLICATION FOR BYPRODUCT MATERIAL LICENSE**	Form approved. Budget Bureau No. 38-R027.4.

INSTRUCTIONS.–Complete Items 1 through 16 if this is an initial application. If application is for renewal of a license, complete only Items 1 through 7 and indicate new information or changes in the program as requested in Items 8 through 15. Use supplemental sheets where necessary. Item 16 must be completed on all applications. Mail three copies to: U. S. Atomic Energy Commission, Washington 25, D. C. Attention: Isotopes Branch, Division of Licensing and Regulation. Upon approval of this application, the applicant will receive an AEC Byproduct Material License. An AEC Byproduct Material License is issued in accordance with the general requirements contained in Title 10, Code of Federal Regulations, Part 30 and the Licensee is subject to Title 10, Code of Federal Regulations, Part 20.

1. (a) NAME AND STREET ADDRESS OF APPLICANT. *(Institution, firm, hospital, person, etc.)*

Naval Undersea Research and
Development Center
San Diego, California 92132

(b) STREET ADDRESS(ES) AT WHICH BYPRODUCT MATERIAL WILL BE USED. *(If different from 1 (a).)*

Naval Undersea Research and
Development Center
San Clemente Island, California

2. DEPARTMENT TO USE BYPRODUCT MATERIAL

Ocean Engineering

3. PREVIOUS LICENSE NUMBER(S). *(If this is an application for renewal of a license, please indicate and give number.)*

None

4. INDIVIDUAL USER(S). *(Name and title of individual(s) who will use or directly supervise use of byproduct material. Give training and experience in Items 8 and 9.)*

F. K. Kawahara

5. RADIATION PROTECTION OFFICER *(Name of person designated as radiation protection officer if other than individual user. Attach resume of his training and experience as in Items 8 and 9.)*

A. L. Smith
W. W. MacKenzie, Alternate

6. (a) BYPRODUCT MATERIAL. *(Elements and mass number of each.)*

(b) CHEMICAL AND/OR PHYSICAL FORM AND MAXIMUM NUMBER OF MILLICURIES OF EACH CHEMICAL AND/OR PHYSICAL FORM THAT YOU WILL POSSESS AT ANY ONE TIME. *(If sealed source(s), also state name of manufacturer, model number, number of sources and maximum activity per source.)*

7. DESCRIBE PURPOSE FOR WHICH BYPRODUCT MATERIAL WILL BE USED. *(If byproduct material is for "human use," supplement A (Form AEC-313a) must be completed in lieu of this item. If byproduct material is in the form of a sealed source, include the make and model number of the storage container and/or device in which the source will be stored and/or used.)*

The by-product material will be used to examine the environmental response of marine/terrestrial radioisotope-fueled thermoelectric energy generators presently under development and to assess the radiological implications in the use of such systems. The program is sponsored and directed by the USAEC's Division of Reactor Development and Technology (DRD&T). The basic test plan for this program is submitted as Supplement No. 1.

Several changes have taken place in the test program since the test plan was written. These are:

(Continued on reverse side)

a. The explosive-operated valves on the exposure test chambers have been replaced by manually-operated valves.

b. The water tank shielding for the capsule handling facility has been replaced by a concrete shielding wall equipped with a viewing window and master-slave manipulators.

c. Test locations include the seaward end of the pier at North Light Harbor, San Clemente Island, as well as underwater locations.

Form AEC-313 (5-58)

TRAINING AND EXPERIENCE OF EACH INDIVIDUAL NAMED IN ITEM 4 *(Use supplemental sheets if necessary)*

8. TYPE OF TRAINING	WHERE TRAINED	DURATION OF TRAINING	ON THE JOB (Circle answer)	FORMAL COURSE (Circle answer)
a. Principles and practices of radiation protection			Yes No	Yes No
b. Radioactivity measurement standardization and monitoring techniques and instruments	See Supplement No. 2		Yes No	Yes No
c. Mathematics and calculations basic to the use and measurement of radioactivity			Yes No	Yes No
d. Biological effects of radiation			Yes No	Yes No

9. EXPERIENCE WITH RADIATION. *(Actual use of radioisotopes or equivalent experience.)*

ISOTOPE	MAXIMUM AMOUNT	WHERE EXPERIENCE WAS GAINED	DURATION OF EXPERIENCE	TYPE OF USE
		See Supplement No. 2		

10. RADIATION DETECTION INSTRUMENTS. *(Use supplemental sheets if necessary.)*

TYPE OF INSTRUMENTS (Include make and model number of each)	NUMBER AVAILABLE	RADIATION DETECTED	SENSITIVITY RANGE (mr/hr)	WINDOW THICKNESS (mg/cm^2)	USE (Monitoring, surveying, measuring)
See	Supplement No. 2				

11. METHOD, FREQUENCY, AND STANDARDS USED IN CALIBRATING INSTRUMENTS LISTED ABOVE.

See Supplement No. 3

12. FILM BADGES, DOSIMETERS, AND BIO-ASSAY PROCEDURES USED. *(For film badges, specify method of calibrating and processing, or name of supplier.)*

See Supplement No. 3

INFORMATION TO BE SUBMITTED ON ADDITIONAL SHEETS

13. FACILITIES AND EQUIPMENT. Describe laboratory facilities and remote handling equipment, storage containers, shielding, fume hoods, etc. Explanatory sketch of facility is attached. (Circle answer) Yes No

See Supplement No. 4

14. RADIATION PROTECTION PROGRAM. Describe the radiation protection program including control measures. If application covers sealed sources, submit leak testing procedures where applicable, name, training, and experience of person to perform leak tests, and arrangements for performing initial radiation survey, servicing, maintenance and repair of the source.

See Supplement No. 5

15. WASTE DISPOSAL. If a commercial waste disposal service is employed, specify name of company. Otherwise, submit detailed description of methods which will be used for disposing of radioactive wastes and estimates of the type and amount of activity involved.

See Supplement No. 5

CERTIFICATE (This item must be completed by applicant)

16. THE APPLICANT AND ANY OFFICIAL EXECUTING THIS CERTIFICATE ON BEHALF OF THE APPLICANT NAMED IN ITEM 1, CERTIFY THAT THIS APPLICATION IS PREPARED IN CONFORMITY WITH TITLE 10, CODE OF FEDERAL REGULATIONS, PART 30, AND THAT ALL INFORMATION CONTAINED HEREIN, INCLUDING ANY SUPPLEMENTS ATTACHED HERETO, IS TRUE AND CORRECT TO THE BEST OF OUR KNOWLEDGE AND BELIEF.

Naval Undersea Research and Development Center

Applicant named in item 1

Date OCT 24 1969

By: W W MacKenzie

W. W. MacKenzie, LCDR, USN

Title of certifying official

Head, Command Administration Department

WARNING.—18 U. S. C., Section 1001; Act of June 25, 1948; 62 Stat. 749; makes it a criminal offense to make a willfully false statement or representation to any department or agency of the United States as to any matter within its jurisdiction.

* U.S. GOVERNMENT PRINTING OFFICE : 1961 O—615963

USNRDL-LR-67-96
27 November 1967

SNAP ENVIRONMENTAL TEST AND RADIOLOGICAL EFFECTS PROGRAM
Basic Test Plan for Ocean Exposure Studies of SNAP-21 Radioisotope-Loaded Fuel Capsule

by

L. W. Weisbecker*
S. Z. Mikhail

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U. S. NAVAL RADIOLOGICAL DEFENSE LABORATORY
San Francisco, California 94135

Supplement No. 1

TECHNICAL MANAGEMENT OFFICE
P. E. Zigman, Head

*Present address: Stanford Research Institute, 333 Ravenswood Avenue, Menlo Park, California 94025.

TABLE OF CONTENTS

I INTRODUCTION

A. Background

Under the sponsorship and direction of the Division of Reactor Development and Technology of the U.S. Atomic Energy Commission, the U.S. Naval Radiological Defense Laboratory is conducting a program to test the environmental influences on marine and terrestrial devices. As part of this program, the effect of the ocean environment on the SNAP-21 Radioisotope Thermoelectric Generator is to be investigated. The approach taken in these investigations and the specific objectives of the experimental program have been described previously in a general way.* The main intentions of the Program are:

1. examine the behavior and permanence of the SNAP-21 fuel capsule under both normal and credible abnormal operating conditions.

2. evaluate SNAP-21 fuel behavior (dissolution, transport, interaction) in the event of containment failure.

It is possible to categorize the marine environmental influences which would act on exposed fuel or fuel subsystem as:

1. corrosion/erosion,

2. marine fouling,

3. radiation interactions with seawater medium.

Both precisely controlled laboratory examination and in-situ ocean evaluations are required to explore the nature and impact of these environmental effects. The laboratory tests are designed to:

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* L. W. Weisbecker, "SNAP-21 Safety Test Program, 1. Basic Test Plan for Ocean Exposure Studies of SNAP-21 Electrically Heated Fuel Capsule Test Systems," U.S. Naval Radiological Defense Laboratory, USNRDL-TRC-67-15, April 1967.

1. develop immediate answers for such variables as corrosion rates to provide data which can be used temporarily in design calculations until long-term marine testing results are available.

2. establish the conditions under which certain ocean environment effects could be predicted by laboratory measurements.

3. develop methodologies which can be used for in-situ ocean examinations.

Concurrent with the laboratory examinations, marine testing will be carried out with fuel subsystem simulations which are electrically heated, with fuel subsystems containing radionuclide fuels and with bare fuels.

Testing with electrically heated mockups will provide data on:

1. effect of marine fouling at different water depths,

2. effect of the ocean-bottom-water interface which may create unique problems,

3. effect of partial burial in the bottom material.

Testing with the fuel subsystems containing radioactive material will provide maximum information on the effects due to release of ionizing energy into the water. Finally, oceanic evaluation of bare fuel exposures will investigate fuel degradation and radioactivity release phenomena.

The present document is the second in a series of three which describes in detail the test plan for the SNAP-21 ocean environment exposure program.

B. Scope

In this test plan, the exposure of two identical radioisotope fueled capsules to the ocean environment is described. The plan considers all aspects of the test, but it emphasizes its implementation. In addition to the test plan, a test Operational Manual/Data Package will be developed. This document will contain detailed data on the test system components: the shipping cask, the exposure chamber, the underwater supports, the recording instrumentation, and the power control circuits. It will thus be a mechanism of supplying the project personnel and management as well as the different groups contributing to the SNAP-21 program with this information.

C. Objective

The specific objective in exposing the radioisotope fueled capsules is to evaluate their behavior in the ocean environment in presence of the high intensity radiation field that would normally be a part of their environment. Irradiation may influence the corrosion and surface reactions of the fuel-containment alloy by altering the properties of the alloy and/or by changing the composition of the ambient environment. Although there has been little work published on the chemical reactivity of irradiated metals, the marked effects of radiation observed in connection with other properties of solids suggest that significant changes may take place in the rates of surface reactions.

The indirect effect of radiation on metallic corrosion through its effect on the environment depends, naturally, on the type and nature of the environment. In aqueous solutions, molecular and ionic species are produced. These are capable of either oxidation or reduction of the metal surface and/or certain of the solutes present. The corrosion rate of the capsule material is expected, therefore, to be influenced by the resulting changes.

II EXPERIMENTAL SYSTEM CONCEPT

A. Test Location

The test will be conducted at the San Clemente Island Ocean Environment Testing Station, which has been previously described.*

B. Ocean Exposure Concept

1. Requirements

Since the primary objective of the test is to determine the long-term integrity of the fuel capsule, this characteristic cannot be assumed in the conduct of the test. Therefore, it will be necessary to provide adequate containment for the test specimen in the event that the containment should become broached. In the event the containment becomes broached, the test will be terminated and the test specimen will be recovered for examination.

Accordingly, two general requirements exist in conducting an ocean environmental exposure test of a radioisotope loaded test specimen: (1) the exposure conditions should be realistic, and (2) precautions should be taken so that the test is radiologically safe under all normal or credible abnormal conditions. These requirements may be mutually exclusive to some extent, with the result that the realism of the exposure situation may be compromised to a degree by the requirements imposed by radiological safety.

The requirements of realism in the exposure environment necessitate that the capsule be exposed in situ to a real ocean environment. The requirements imposed by radiological safety are best met by providing shielding for the test specimen during emplacement, operation, and recovery and providing absolute containment for the test specimen in the event that the capsule should become broached.

2. Exposure System Description

An ocean exposure system concept has been devised which satisfies the experimental exposure requirements described above for radioisotope

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* Op. cit.

loaded fuel capsules. The exposure system is composed of the following functional subsystems: (1) the exposure shield chamber, (2) the sea-water circulation system, and (3) the monitoring and control apparatus. A schematic diagram for the conceptual system is shown in Figure 1.

a. Exposure Shield Chamber

The exposure shield chamber serves three functions. (1) It provides a support structure in which the radioisotope-loaded test specimen may be exposed to the ocean environment; (2) The test specimen can be isolated within the chamber if the situation so demands; (3) It provides shielding for the test specimen during emplacement, operation, and recovery.

A sketch of the exposure shield chamber concept is shown in Figure 2.

In operation, the exposure shield chamber is suspended from a buoy at a depth of 75 feet in water 130 feet deep. Seawater flows into the exposure shield chamber from the bottom port, passes over the test specimen maintaining it at a relatively low temperature, and passes out through the top port. The exposure shield chamber is designed to be watertight if the inlet and outlet ports are sealed. Temperature sensors are provided to measure water temperature in the exposure shield chamber at the inlet and outlet ports and at two locations near the test specimen. The test specimen is held in place by alumina standoff pieces which are attached to lugs provided on the inner cylinder wall and the inside surface of the top cap. These standoff pieces provide electrical insulation of the test specimen from the exposure shield chamber and so minimize the possibility of galvanic coupling with the chamber materials.

The solenoid valves at the inlet and outlet ports are arranged to isolate the interior of the exposure shield chamber upon loss of power to the system. These valves are normally closed but are held open during operation by continuous electrical power to the solenoids. In addition, they are wired such that if any one solenoid shorts or opens, the power is also cut to the other.

In addition to the solenoid valves which provide isolation for the exposure shield chamber, explosive operated valves are positioned outside the solenoid valve isolation envelope to provide the capability for remotely activated permanent isolation of the exposure shield chamber

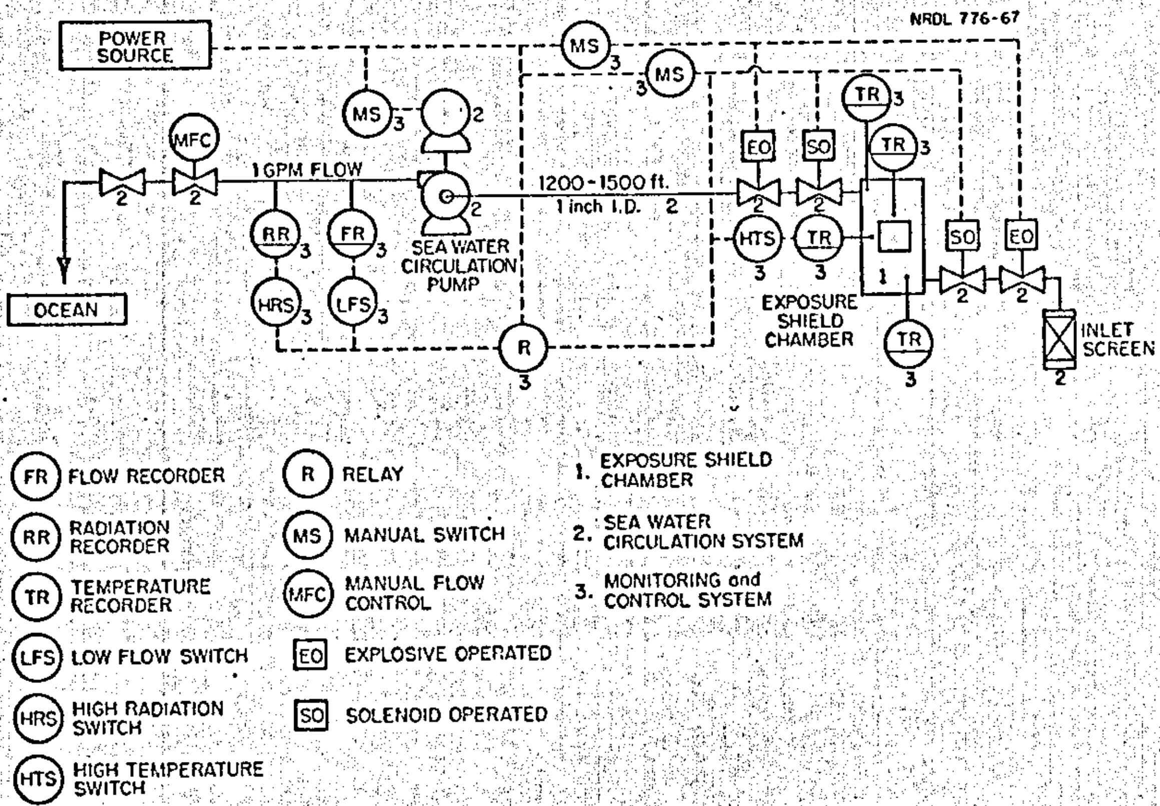

Figure 1. Schematic Diagram Exposure System

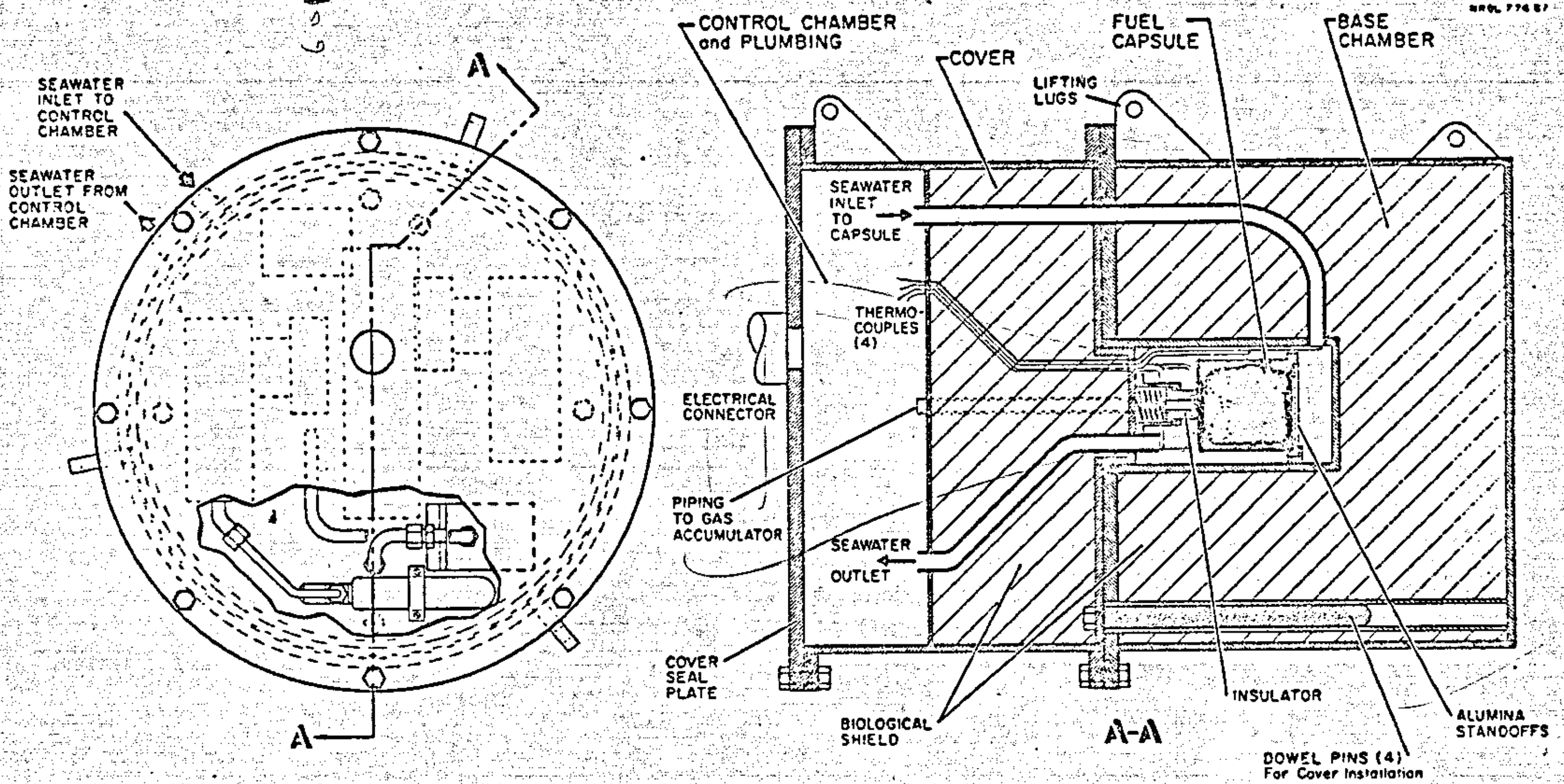

Figure 2. Schematic Diagram of Exposure Shield Chamber Concept

interior. The explosive operated valves are ball valves having a pneumatic operator which is actuated by a small gas bottle controlled by a normally closed explosive valve. Therefore, these valves may be reset and reused by changing a spent gas bottle and its explosive valve.

Under conditions of isolation, the temperature of the contained water will increase and it will expand and also radiolytic gases may be generated. However, the heat transfer from the test specimen to the external seawater in the isolated exposure shield chamber is sufficient to preclude boiling of the interior water at the surface of the test specimen.

Provisions are incorporated into the exposure shield chamber isolation system to accommodate liquid expansion and gas generation. A piston type accumulator is communicated to the seawater inlet. This unit is precharged with gas such that it will accommodate expansion within the exposure shield chamber as a function of the pressure-volume characteristics of the isolated system. Pressure relief and check valves are in a line communicating the top of the exposure shield chamber with the effluent line and by-passing the outlet solenoid and explosive operated valves. Therefore, the accumulator and pressure relief valves work together to insure that only gases are vented from the exposure shield chamber. The accumulator is sized so that liquid expansion and a gas bubble may be accommodated. The pressure relief valve is set so that it will operate within a pressure range corresponding to a gas bubble within the chamber. A schematic diagram of the exposure shield chamber isolation system is shown in Figure 3.

All of the exposure shield chamber isolation system components and piping are contained within a watertight chamber incorporated within the cap of the exposure shield chamber. Therefore the external seawater circulation system components consist of a screen filter attached to the inlet pipe coupling and the effluent hose attached to the outlet pipe coupling. All of the instrumentation and power control leads are brought through a common watertight electrical connector receptacle in the top of the exposure shield chamber.

The test specimen is loaded into the exposure shield chamber at San Clemente Island. The test specimen is shipped from Battelle Northwest Laboratories in the shipping cask in which it was originally shipped from Oak Ridge National Laboratory (see Section IIIA below).

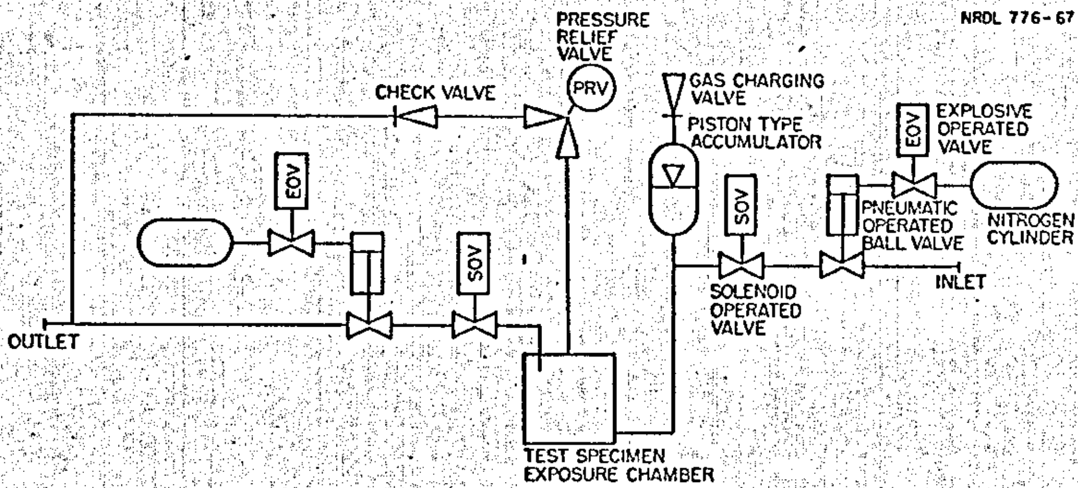

Figure 3. Schematic Diagram - Exposure Chamber Isolation System

At San Clemente Island, the test specimen is transferred from the shipping cask to the exposure shield chamber under water in a tank which provides at least three feet of water shielding for the operators.

b. Seawater Circulation System

The seawater circulation system consists of a hose which connects the exposure shield chamber on one end and the monitoring and sampling station on shore on the other end. In between these two terminals a mechanically driven pump is placed to transport seawater from the exposure shield chamber on the suction side to the shore station and thence return it to the ocean. The nominal flow rate through the system is one gallon per minute.

The pump is located on shore where it is readily available for maintenance. However, this requires a suction line approximately 1200 feet long. Therefore, a relatively large diameter suction line is used together with a self-priming pump which is positioned such that the suction lift is no greater than 15 feet. The hydraulic parameters for a 1-1/4 inch internal diameter suction hose are shown in Table 1. This hose results in a relative long transit time for a fluid element, but the friction head loss is quite low.

c. Monitoring and Control System

The monitoring and control system establishes the safety of the test with continuing exposure time as well as provides data indicative of the radioisotope containment integrity. A sample of the exposure shield chamber effluent is continuously monitored for radioactivity characteristic of the radioisotope test specimen. In addition, periodic samples may be taken for precise radiochemical analyses. At a given concentration of dissolved radioisotope in the effluent, it will be desirable to isolate the exposure shield chamber from the ocean and to commence recovery operations of the test specimen.

For the monitoring system to be feasible, several requirements must be met: (1) the efficiency of the continuous radiation monitor must be such that the concentrations of radioisotope in the effluent less than or equal to the desired maximum or allowable concentration can be detected; (2) the detector should be directly coupled to the potential contaminating source; (3) the on-line monitor must be continuously in service and in calibration.

TABLE 1

FLOW CONDUIT HYDRAULIC PARAMETERS

Conduit Internal Diameter	1.25 inches
Conduit Length	1200 feet
Flow Velocity	0.262 ft/sec
Transit Time	76.5 minutes
Friction Head Loss	0.254 psi
Contained Volume	76.5 gallons

Commercially available liquid monitoring systems have the following sensitivities for Strontium-90 in water: a multi-tube Geiger detector will indicate 46 counts per minute above background at a concentration of 1×10^{-5} μc/cc while a scintillation detector will indicate 17 counts per minute above background at a concentration of 1×10^{-6} μc/cc.* Accordingly, the multi-tube Geiger detector is to be utilized because of adequate sensitivity and greater inherent ruggedness and reliability than the scintillation detector.

The detector is coupled to the potential contaminating source through approximately 1200 feet of 1-1/4 inch i.d. flow conduit separating the detector on shore and the test specimen in the exposure chamber. At normal system flow rates, this results in a transit time of an element of fluid of 76.5 minutes. Assuming a 76.5 minute delay between the time a contaminating release takes place and the detection of the release and subsequent system isolation, the flow conduit may contain 76.5 gallons of contaminated sea water. Closer coupling between the detector and the source would require a detector capable of operating below the surface of the ocean at a distance from the associated electronic equipment. While closer coupling is desirable, it is felt that the added cost of this capability is not warranted.

The calibration of the radiation monitor will be ensured by periodic radiochemical determinations of the effluent and by periodic checkouts of the monitor with radiation standards. Should the monitor fail in a gross manner or should the monitor not function for any reason, the test specimen will be automatically isolated within the exposure shield chamber.

Two other system parameters will be continuously monitored in addition to the radiation level of the effluent. The seawater circulation flow rate will be monitored on shore while the seawater temperature within the exposure shield chamber will be measured at several locations.

If the circulation flow rate decreases below a set value, approximately 1/3 of the normal value, the exposure shield chamber is automatically isolated by closing the solenoid valves. Under low flow

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* See, for example, manufacturer's data on Victoreen Instrument Company Detector Models VMS-1A and VMS-1B.

rate conditions, the delay time for a sample to traverse the distance between the exposure shield chamber and the radiation monitor can be so great that the risk of allowing a possible containment failure to go undetected for such a period of time would be undesirable. In addition, a low flow can be indicative of other hydraulic circuit problems which should require test specimen isolation.

Under conditions of low flow within the exposure shield chamber, the temperature of the water will rise. The enthalpy rise of the water under normal flow conditions will result in a temperature rise of approximately 1°F between the inlet and outlet. This will not be detectable with the processing type of sensing and readout instrumentation normally utilized. However, if the flow rate should decrease to a tenth of the normal value, the temperature increase in the outlet water flow will be sufficient to be detected. Such a temperature increase would occasion the automatic isolation of the exposure shield chamber. A situation where the flow rate within the exposure shield chamber would decrease but not that at the shore station would be a leak in the flow conduit between the exposure shield chamber and the pump.

3. Exposure System Arrangement

The exposure shield chamber will be suspended at a level 75 feet from the surface in water 130 feet deep. This level will provide exposure to the euphotic zone in a region of high photosynthesis production as well as being sufficiently deep to be undisturbed by surface craft and all but large storm surges. The depth is sufficiently far from the bottom to remain unaffected by bottom interaction and is readily accessible to divers for observation and minor maintenance. An electrically heated test specimen is positioned under similar conditions* to provide a direct comparison and a standard for comparison with other exposure conditions.

The suspension system for the exposure shield chamber is an underwater buoy held in place with a concrete anchor on the bottom. The electrical cable is brought down the suspension system support cable and is then run along the bottom to a pier which extends approximately 150 feet out from the shore. The path of the seawater effluent line from the exposure chamber to shore parallels the electrical cable. A schematic layout of the suspension system is shown in Figure 4.

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* Op. cit.

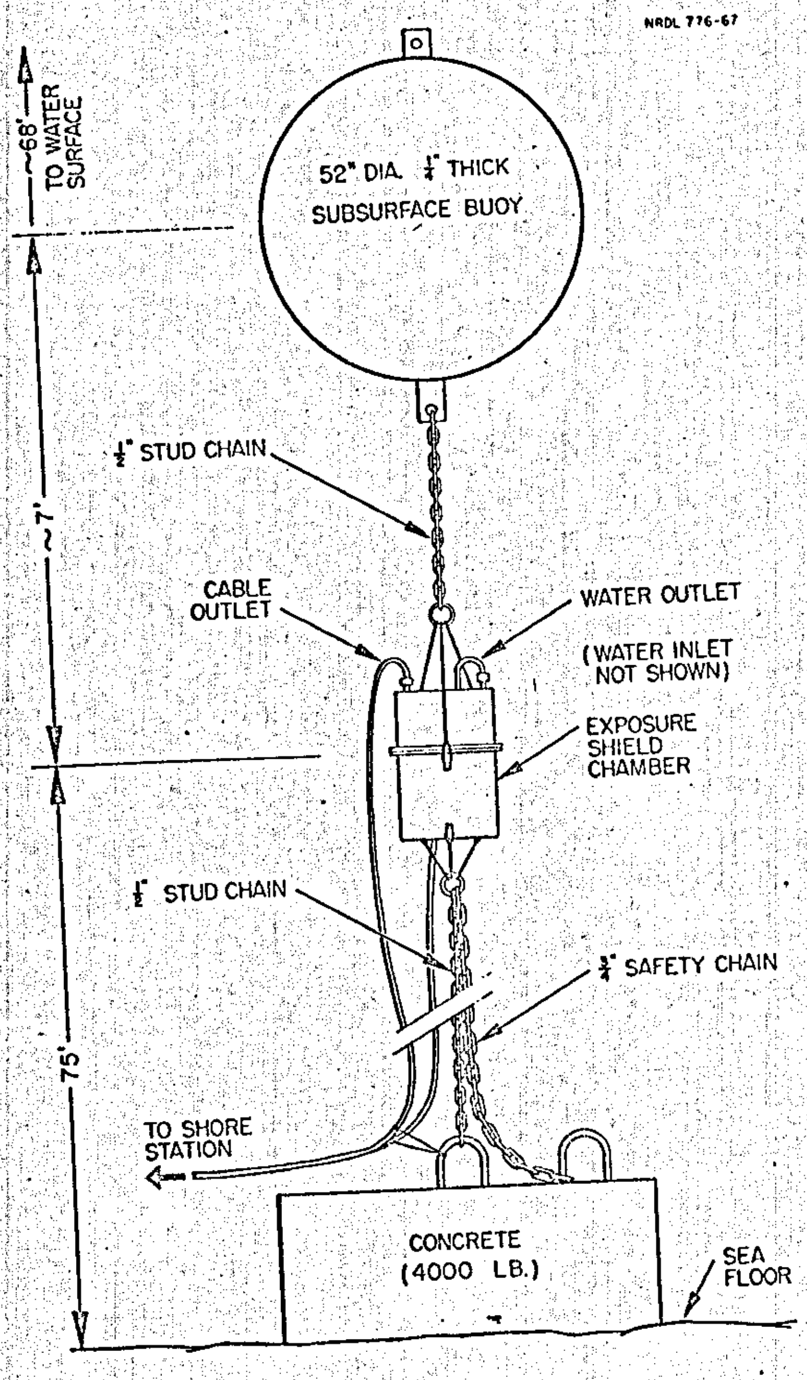

Figure 4. Underwater Exposure Shield Chamber Suspension System Concept

The seawater effluent line is brought up to a pump station located in the pier support structure such that the pump inlet is approximately 15 feet above low tide level. The pump outlet is brought to the pier level where it is run to a radiation monitor detector and a sample take-off point and then returned to the ocean. This subsystem comprises the pier station. The electrical cable is brought up to the pier level at a point well removed from the surf action and is led to the shore station.

The shore station houses the electrical recording, monitoring, and control equipment in a weatherproof structure. A schematic layout of the exposure system is shown in Figure 5.

4. Materials Considerations

In placing a system in the ocean environment which incorporates fluid flow passages and heat transfer surfaces, the tendency for marine fouling on surfaces must be considered, as well as the tendency of many materials to corrode in a seawater environment. In addition, in a test system in which metallic corrosion is an important process under study, potential galvanic effects should be minimized.

Any system design is the result of a series of compromises arising from conflicting objectives and requirements. Where appropriate, the materials of construction have been identified in the system component sketches. In some cases it is apparent that these selections may be deficient in one or more of the considerations listed above. In these situations, some other constraint has prevailed in the material selection. Further consideration as the design is developed may show this preliminary judgment to have been premature.

5. Radiological Safety

As a general precaution, all planned operations or manipulations involving exposure to radioactive materials or ionizing radiation will be carried out under radiological health supervision in accordance with Federal and State regulations. In addition, certain mechanical and functional features are incorporated into the test specimen exposure system to render any unplanned exposure extremely unlikely. These safeguards are described below and are expected to form the basis for approval by the Federal and State Radiological Health authorities to conduct the test.

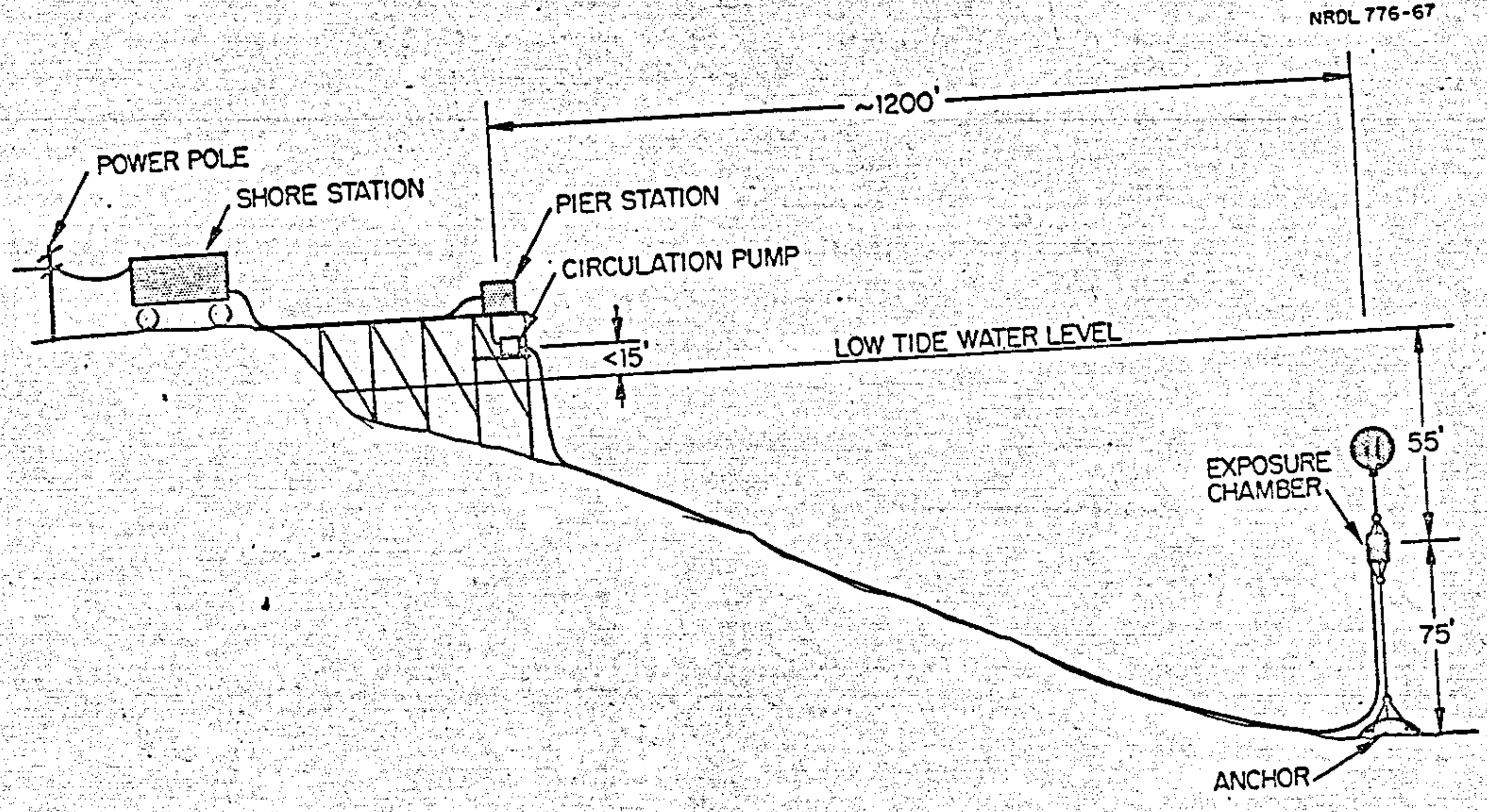

Figure 5. Exposure System Arrangement

Under normal conditions the radioisotope material is contained within a welded shell of highly corrosion resistant alloy which has been inspected nondestructively for soundness and leak-tightness. During the entire sequence of test operations, this capsule is provided with a biological shield. The nominal level of biological shielding is specified to result in an exposure dose rate no greater than 200 mr/hr at the surface of the shielding. The test specimen is shipped to the test site in an Atomic Energy Commission approved Oak Ridge shipping cask. The transfer from the shipping cask to the exposure shield chamber is made under 3 feet of water and the exposure shield chamber itself contains 5-1/2 inches of lead shielding. Additional biological shielding is provided by the surrounding water normally interspersed between the test specimen and the sphere of human habitation during exposure operations.

It must be considered as credible that under long-term exposure to seawater, the fuel encapsulant could become broached through one of the corrosion processes. In this situation, transport of radioactive materials at concentrations greater than that normally considered acceptable within the marine environment must be prevented. This problem has two aspects: 1. Knowing when containment integrity is lost; 2. Taking action to prevent radioisotope transport. The first aspect is provided for by continuously monitoring the water being passed over the test specimen for its radioactive material concentration. If the capsule integrity is lost as indicated by the radiation monitor or if for some reason monitoring cannot be accomplished, then the prevention of radioisotope transport to the environment, which is necessary in the first case and as a precautionary measure in the second case, is accomplished by isolating the specimen and its water environment within the exposure chamber.

If the exposure shield chamber should be isolated because of a high radiation level at the radiation detector located on the pier, the seawater effluent line may contain some 76 gallons of contaminated water. It may not be desirable to return this water to the ocean, and so it must be collected for decontamination or disposal in an acceptable manner. The water is collected into two 55-gallon plastic lined drums using the following procedure. The seawater circulating pump is started, the effluent line is disconnected from the exposure shield chamber by divers, and the water is collected at the nominal system flow rate into the drums from the sample outlet until both drums are full. Radiochemical assay of both drums is completed before disposal or decontamination is undertaken.

A situation which is not necessarily radiologically unsafe but one which is undesirable is the separation of the exposure shield chamber from its moorings. Even though the radioisotope capsule would very likely remain isolated from the external environment within its biological shield, the loss of the exposure shield chamber and its enclosed test specimen could result in a hazardous situation. Two safeguards are engineered into the exposure shield chamber suspension system to render the loss of the exposure shield chamber through separation from its moorings exceedingly remote.

The support chain between the underwater buoy and the exposure shield chamber is designed to separate at lower stresses than the chain between the exposure shield chamber and the anchor. However, the weaker chain is rated for stresses greater than any expected from storm-caused wave surges. The likelihood of a support chain failure which would allow the exposure shield chamber and the float to become free-floating is very small with this system. The second safeguard is a slack safety chain attached to the exposure shield chamber and to the anchor. This chain is rated for stresses at least equal to either of the support lines. Therefore, in order for the float and exposure shield cask to float free, the failure of two chains at stresses much less than that at which each is rated, is required. This seems an unlikely event, which, with periodic inspection of the chains, should be almost incredible.

Several of the test exposure operational parameters are measured such that an out-of-specification indication automatically initiates actions designed to prevent possible radioactive material release to the environment. These parameters are listed in Table 2 together with some of the possible causes and the automatic safety actions. In all cases of questionable operating parameters, the safety action taken is isolation of the test specimen from the environment within the exposure shield container.

TABLE 2

Indication	Possible Causes	Safety Action
Low Flow	Line Plug	Shut-Down Circulating Pump
	Pump Failure	Close Inlet and Outlet Solenoid Valves
High Radiation	Capsule Containment Leaks	
	Contaminated Water	
	External Source Near Detector	
High Temperature	Break in Hose	
	Line Plug	
	Pump Failure	
Loss of Power	Generator Failure	
	Transmission Line Break	
	Circuit Breaker Actuation	

III EXPERIMENTAL PROGRAM

A. Implementation

A sequence diagram depicting the steps involved in implementing the test program is presented in Figure 6. Also shown are the interrelationships between each step and between the various responsible organizations. The NRDL tasks include the test hazards analysis and licensing approvals, as well as three hardware units: 1) the exposure shield chamber, 2) the underwater rig which includes the support structure, electrical cables, and effluent lines, and 3) the shore station which includes the effluent sampling point, the monitoring, control, and recording electrical apparatus, and the seawater circulation pump.

The radioisotope fueled test specimen would be manufactured by the SNAP-21 contractors to SNAP-21 specifications. The 3M Company would manufacture the capsule and capsule liner parts. These would be sent to ORNL where the fuel body is manufactured. There the capsule is loaded and welded. The loaded capsule is then sent to Battelle Northwest Laboratories for nondestructive testing of the capsule and weld.

After the nondestructive testing is completed, the test specimen is loaded into the shipping cask in which it was shipped from ORNL and is shipped via NRDL to the Long Beach, California, Naval Shipyard. From here the shipping cask is transshipped by the Naval Undersea Warfare Center to the NRDL Marine Environmental Test Station on San Clemente Island.

The ORNL shipping cask is uranium-shielded and is rated for 150,000 curies of Cobalt-60. The overall dimensions are 35-1/8 inches in diameter and 38 inches high, and the total weight is about 11,700 lbs. The cask is provided with an expanded metal personnel shield and a shipping skid.

On San Clemente Island, the test specimen is transferred from the shipping cask to the exposure shield chamber. In order to facilitate the transfer operation and to provide radiological protection for the operating personnel, a specially designed transfer facility is provided. This facility consists of a transfer tank placed on a concrete support pad. The support post for a 3-ton capacity jib crane and hoist is placed behind the transfer tank. The transfer tank is of sufficient size such that a minimum of 3 feet of water shielding can be provided the operating

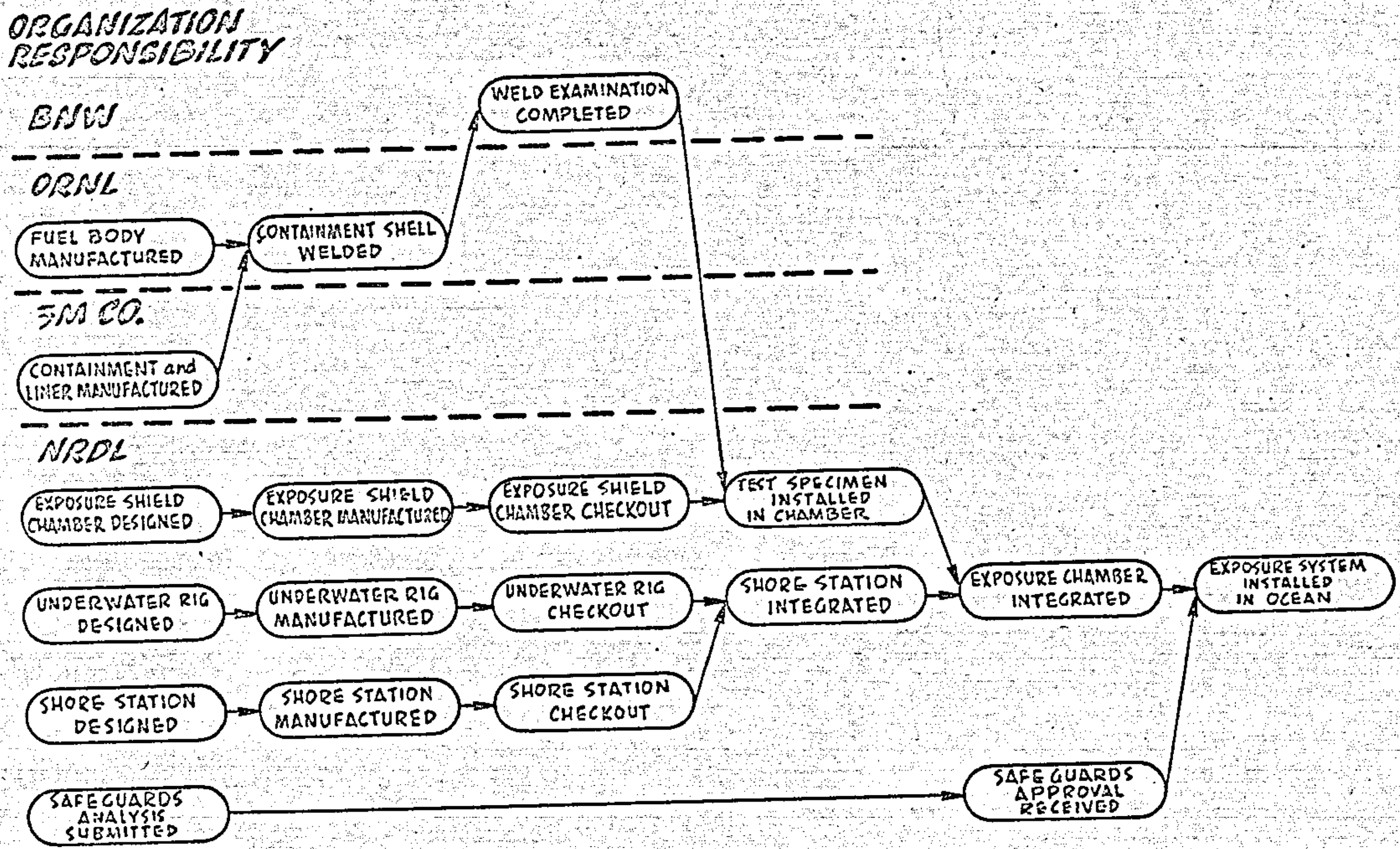

Figure 6. Test Implementation Sequence Diagram

personnel during the underwater transfer from the shipping cask to the exposure shield chamber. The hoist is of sufficient capacity to remove and replace the top of the shipping cask, which is the maximum weight that it will be required to lift. The transfer facility is located adjacent to the access road in the North Light Harbor Pier area. A sketch of the transfer facility concept is shown in Figure 7.

The shipping cask is transported to the transfer facility on a truck, and it is lifted with a truck crane. At the transfer facility, the expanded metal personnel shield is removed from the shipping cask and it is lifted from its shipping skid. The lid bolts and the pipe plug on the lid vent are removed from the shipping cask. The transfer tank is then filled with seawater or fresh water if a sufficient quantity is available. The shipping cask is lowered into the transfer tank with a truck crane. The base of the exposure shield tank is then lowered into the transfer tank using the hoist. The top of the shipping cask is removed next with the hoist. By working from a platform at the front of the tank and using a long-handled tool, the fuel capsule is lifted from the shipping cask and placed inside the exposure shield chamber.

The cap of the exposure shield chamber is then lowered onto the base in the transfer tank and is guided into place with dowel pins built into the cap. The entire exposure shield chamber is lifted from the transfer tank with the hoist and placed in a 55-gallon drum of water to provide temporary cooling. The top is bolted onto the base. The exposure shield chamber and its water drum is then lifted and transported to the work barge with the truck and truck crane.

The effluent hose reel and electrical control cable reel are placed aboard the work vessel, as are the exposure shield chamber support and anchor system. The effluent hose and electrical control cable are attached to the shore station terminals, and they are payed out as the work vessel is moved to the test location. At the test location, the exposure shield chamber is removed from the water drum which has provided temporary cooling. The electrical control cable and effluent hose and inlet filter are attached to the exposure shield chamber. The exposure shield chamber is then integrated with the suspension and anchor system, and the entire unit is emplaced using a floating crane or a crane on the work vessel.

The ORNL shipping cask is to be returned to Oak Ridge. The base of the cask is removed from the transfer tank with the truck crane. Both

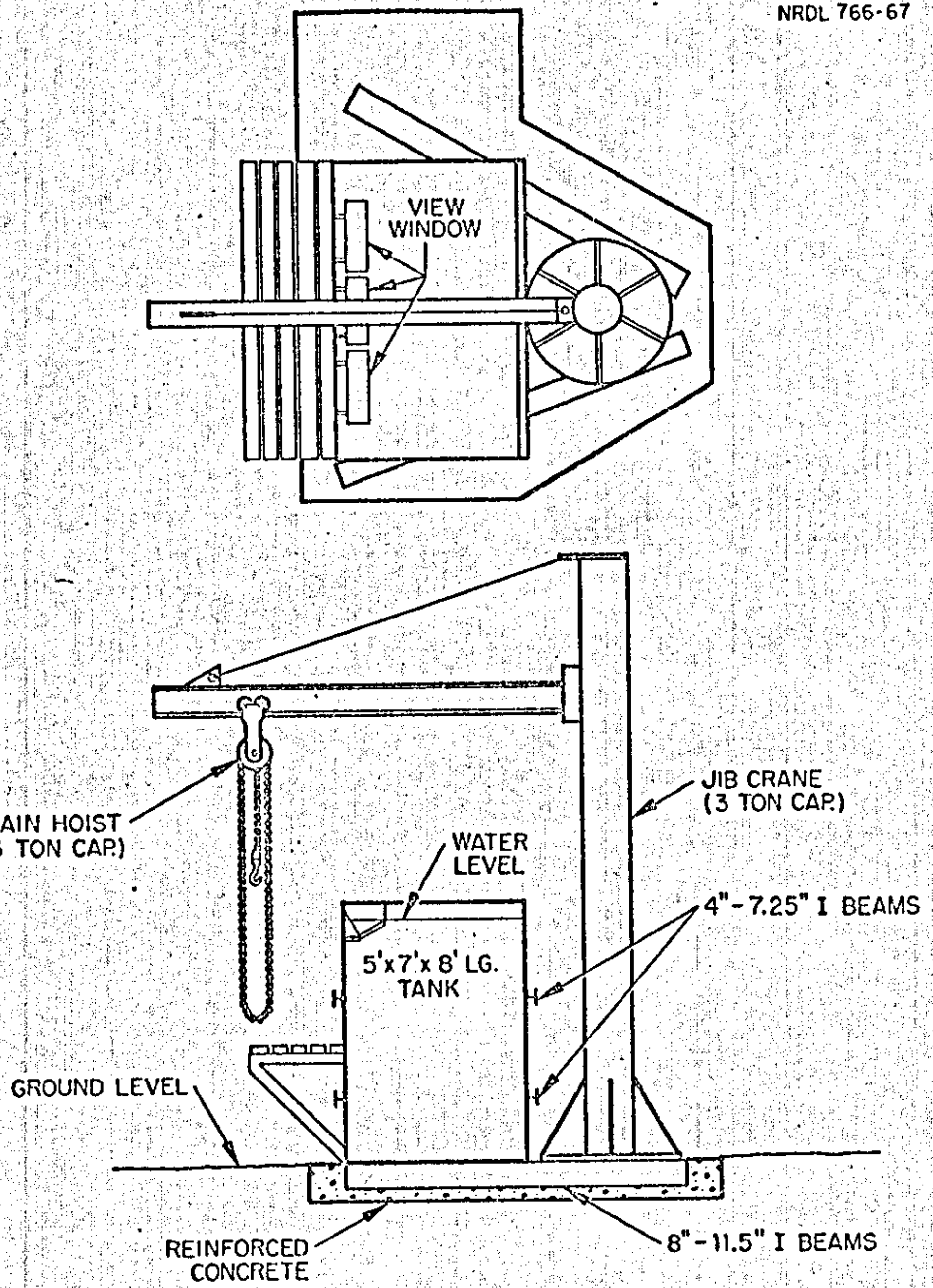

Figure 7. Capsule Transfer Facility Marine Environment Test Station S.C.I.

the top and the base are rinsed with fresh water, and the top is replaced using the truck crane. The personnel shield and shipping skid are re-assembled to the shipping cask, which is then returned to the owner.

B. Operations

Inasmuch as the results of the ocean environmental exposure of the radioisotope loaded fuel capsule are to be compared with the results obtained from the electrically heated test specimens, the pre- and post-exposure evaluations of the capsule will require similar data and procedures. The post-exposure evaluation of the radioisotope-loaded fuel capsule will be complicated by the necessity for performing some of the measurements remotely in a hot cell facility.

Because of the necessary involvement of Oak Ridge National Laboratory in the fuel material examination, it would be most efficient to extend this involvement also to the fuel encapsulent. Therefore, those operations commencing with the requirement for remote handling in a radioactive materials facility would best be performed by that laboratory. The detailed post-exposure examination procedures will be developed in conjunction with ORNL.

Certain pre-exposure information is required in order to facilitate the evaluation of any exposure effects as determined in the post-exposure examination of the test specimens. The following pre-exposure data and information will be acquired from the appropriate sources.

1. Raw material and component specifications
2. Raw material and component receiving inspection records
3. Vendor certification records
4. Engineering drawings with all change orders and revisions
5. Process and fabrication specifications
6. Fabrication photographic documentation
7. Fabrication quality control and as-built inspection records
8. Results of functional testing and calibrations
9. As built weights and surface roughness measurements

In addition, representative samples of test specimen materials and test welds will be obtained and saved so that comparison standards will be available for any post-exposure metallographic examinations. This material may consist of scrap if suitably sized pieces are available; however, the source of the scrap pieces should be identified.

The post-exposure evaluations will be conducted primarily to identify and evaluate material degradation which has resulted from the environment exposure. This material degradation will most likely be the result of the separate or coupled effects of thermal conditioning, radiation damage, and corrosion processes. Therefore, the post-exposure examinations will concentrate on identifying and characterizing areas in the fuel encapsulant of pitting, cracking, and uniform corrosion together with microstructural transformations. Although the fuel material is not primarily under test (in that the cladding integrity determines test duration), some examinations of the fuel will undoubtedly be desirable after a long-term operation. If a defect should develop in the containment, the effect of water on the fuel body properties as well as the amount of fuel lost will be an important experimental result.

The detailed post-exposure examination will be developed with consideration of the test operating experience and the knowledge gained from the electrically heated test specimen exposure program. However, the following sequence of operations could comprise the post-exposure examination.

1. A visual and photographic (color and black and white) examination of the specimen as removed from the environment. This examination will be desirable if marine growth results in significant thermal fouling of the electrically heated test specimen. Because of the fragile and perishable nature of some types of marine growth, this examination must be performed while the test specimen is in a seawater environment. Therefore, procedures and the necessary special optical apparatus will be developed to accomplish this examination at the test site. This examination could be performed in the water filled transfer pit during the sequence of operations in which the test specimen is transferred from the exposure shield chamber to the ORNL shipping cask.

2. The next examination operations will take place in a hot cell facility. The shipment from the test site to the hot cell facility will be accomplished with the test specimen in the dry state. This will effectively calcine any marine deposits on the test specimen. At the hot cell facility, a visual and photographic examination of the test specimen will be accomplished in the as-received condition.

3. The test specimen is next cleaned of any surface films and deposits. Procedures will be developed utilizing both mechanical and chemical processes. Visual and photographic examinations of the cleaned test specimen are then carried out.

4. Dimensional, weight, and surface roughness measurements are made.

5. If the specimen has indicated a loss of capsule integrity, the leak is located by an appropriate nondestructive method.

6. At this point, the test specimen is cut open and the fuel body is removed. The fuel body receives an appropriate examination by the fuel manufacturer, the Oak Ridge National Laboratory.

7. If the specimen has indicated a leak which has been confirmed and located, the leak area is subjected to metallographic examination. If the specimen has not leaked, samples are obtained of the containment material and weld areas for metallographic examination and comparison with the reserved standards.

8. If the metallographic examination shows areas of unusual surface effects or microstructure, specimens may be subjected to further analyses to determine the composition of these constituents.

The test operations will be integrated into the operations of the electrically heated test specimens and the same environmental measurement data will serve both test programs. The exposure system data indicated by the sensors and records on Figure 1 will be obtained on a continuous basis, although the time period between recorded data points may be relatively long (several hours) after test startup and checkout. The system is designed for unattended operation although a daily watchman type surveillance will be carried out. Any action that automatically isolates the exposure shield chamber will activate an alarm which will require inspection by project personnel. All automatic systems are provided with manual override so that the system may be checked out and put back in operation after an isolation incident should the inspection by project personnel indicate that this is acceptable.

C. Schedule

A program implementation schedule is shown in Figure 8. This schedule assumes an integration with the entire SNAP-21 Safety Test Program, and so perturbations in other parts of the program may necessarily be reflected in this schedule. The schedule also assumes an availability date for the radioisotope-loaded test specimen.

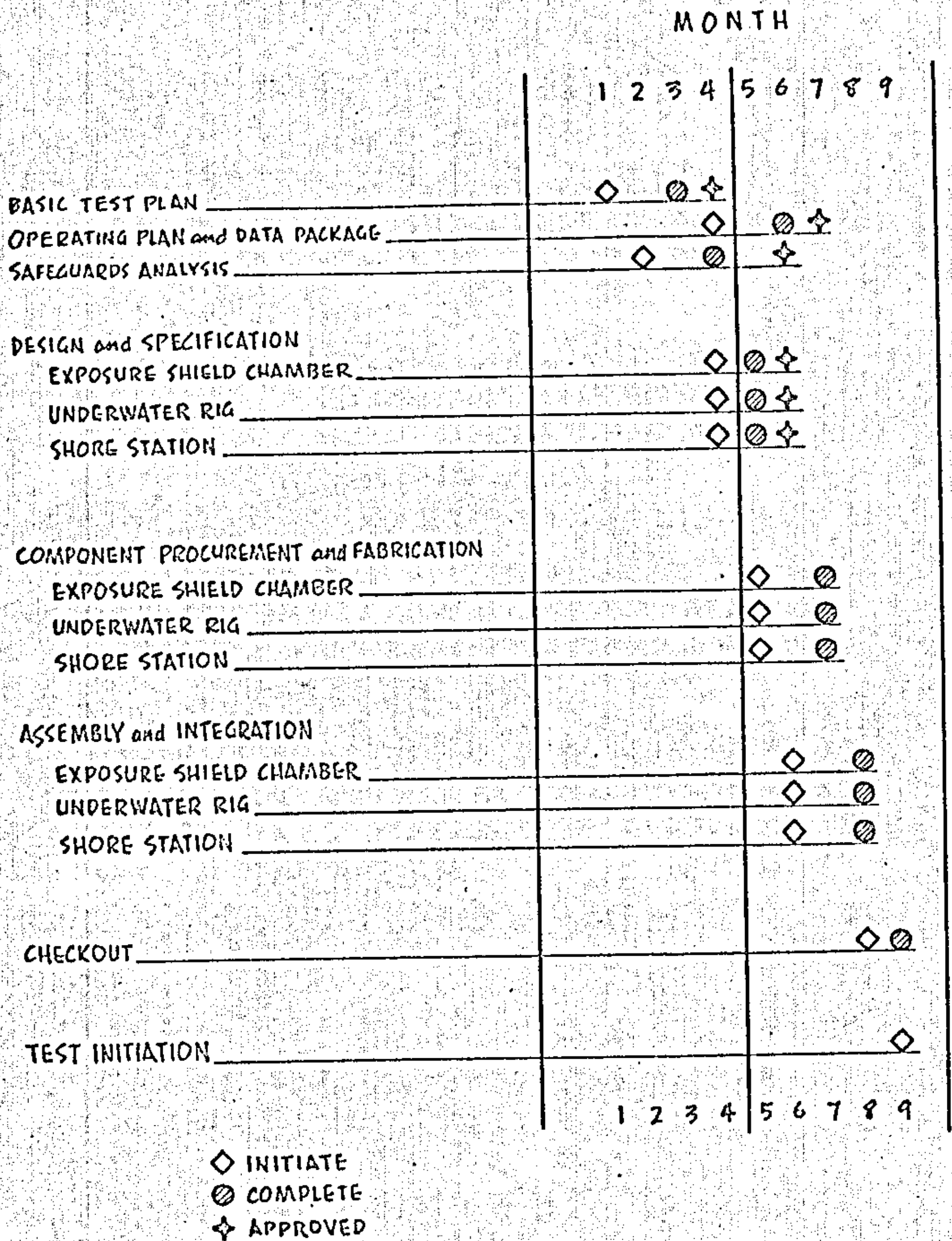

Figure 8. Program Schedule

SUPPLEMENT NO. 2

(Items 8 and 9)

Qualifications of Personnel Using and Supervising Safety Program for By-product Materials.

1. A. L. Smith, RSO

Health Physicist, Safety Division, Command Administration Department, NUC, starting 3 November 1969. (The RSO is available starting 1 October 1969 for health physics services on a temporary additional duty basis.)

Head, Health Physics Division, NRDL, (U.S. Naval Radiological Defense Laboratory), San Francisco, California, February 1962 to November 1969.

Head, Radiological Safety Branch, Health Physics Division, NRDL, July 1956 to February 1962.

Health Physicist, NRDL, October 1951 to July 1956.

Health Physicist, General Electric Corporation, Hanford Atomic Products Operation, January 1948 to October 1951.

BS in Chemical Engineering, University of Louisville, Louisville, Kentucky, June 1938. Certified by American Board of Health Physics, December 1960.

2. LCDR W. W. MacKenzie, Alternate RSO

Served aboard nuclear submarine USS U.S. Grant (SSBN-631) for period of two years. Worked as Radiation Team member.

Received Radiation Safety Training at the U.S. Naval Submarine School, New London, Connecticut.

Received Radiation Safety Training at the U.S. Naval Postgraduate School, Monterey, California.

3. F. K. Kawahara, Project Engineer for the SNAP-21 Tests.

General Engineer, NUC, August 1969 to present.
General Engineer, NRDL, 1958 to August 1969.
Mechanical Engineer, NRDL, 1950 to 1958.
BS in Mechanical Engineering, University of California, 1950.

Served as Deputy Project Officer and Project Officer for Fallout, Inhalation and Ventilation Projects at Field Operations Sunbeam, Hardtack, Redwing, Teapot, Wigwam, and Castle.

4. Additional consulative support will be requested, as needed, from qualified personnel in the NUC organization as well as from higher headquarter sources, such as the Nuclear Power Division, Naval Facilities Engineering Command, Falls Church, Virginia.

SUPPLEMENT NO. 3

(Items 10, 11, and 12)

Monitoring Procedures and Instruments

1. Monitoring devices available at NUC include the following:

Instrument and/or Type	Qty on Hand	Range	Window Thickness mg/cm^2	Purpose
Side Window GM (Several types including Eberline E112B, Berkeley 2750, and lm-113 AN/PDR)	10	0-0.2 mr/hr 0-2.0 mr/hr 0-20 mr/hr	30	β-γ contamination monitoring
Ionization Chamber (CP's) (Including Victoreen 740 and El-tronics CP3D)	5	0-0.1 rad/hr 0-1.0 rad/hr 0-10 rad/hr	30	β-γ radiation monitoring
End Window GM (Berkeley 2750)	2	0-500 c/m 0-5,000 c/m 0-50,000 c/m	<4	low energy β monitoring
End Window GM and enclosed GM (AN/PDR-27J)	2	0-0.5 mr/hr) 0-5.0 mr/hr) 0-50 mr/hr) 0-500 mr/hr)	4 ~500	low energy β monitoring γ monitoring
Alpha Gas Proportional (Eberline PAC 3G)	1	0-1,000 c/m 0-10,000 c/m 0-100,000 c/m	~1	α contamination monitoring
Alpha Scintillation (Eberline PAC 1SA)	1	0-2,000 c/m 0-20,000 c/m 0-200,000 c/m 0-2,000,000 c/m	~1	α contamination monitoring
Dosimeters, Self-reading	25	0-200 mr	--	personnel γ monitoring
Film badges (Standard Navy Film Badge)	25	20 mr - 30 R	--	personnel β-γ monitoring
Air Sampler (Staplex, high volume)	3	25 cfm	--	α-β-γ aerosol collection
Air Sampler (Schmidt, low volume)	1	2 cfm	--	α-β-γ aerosol collection
Air Sampler (Gelman, low volume)	3	2 cfm	--	α-β-γ aerosol collection

Monitoring Procedures and Instruments

Instrument and/or Type	Qty on Hand	Range	Window Thickness mg/cm^2	Purpose
Nuclear Chicago Counting System	1	--	Windowless	α-β-γ air, water, and wipe sample counting
End Window GM Counting System	1	--	~ 2	β air,water, and wipe sample counting

Also on-board in another group, but available to the health physics function on an as-needed basis, is a Sharp Wide-Beta low-background counting system (gas proportional). This system has backgrounds of the order of 1 c/m Beta, (β), 5 c/hour alpha (α), and detection efficiencies of 25% or better. This system will be used for the counting of bio-assay samples.

2. Instruments Calibration

Portable radiation detection instruments will be given a formal calibration at least semi-annually. At present, no standard radiation source is available to accomplish ion chamber calibration in the 100 mr/hr and higher ranges. These instruments will be calibrated in a commercial facility such as Radiation Detection Company, Mountain View, California, at the required intervals.

A small (~1 mc) Co^{60} will be used to calibrate the low range portable instruments and as a check source for the ion chamber instruments. Operational checks will be made on a daily basis for each instrument as it is used.

Counting systems will receive background and source response checks each day they are used. Commercially available calibrated beta (β) and alpha (α) counting standards will be used for the source response checks.

3. Film Badges, Dosimeters, and Bio-assay Procedures

Film badges will be issued to and worn by all personnel whose duties involve work with by-product materials. Badges will be processed on a monthly basis by mailing to the National Naval Medical Center, Bethesda, Maryland, the Navy's main central processing center.

Pocket dosimeters will be worn by all personnel entering a radiation (75 mr/hr) area. Dosimeters will be read and logged on a daily basis. Any off-scale (>200 mr) reading will be cause for immediate processing of the film badge.

Film results will be entered, upon receipt in the Navy DD 1141 form, the Occupational Exposure Record.

Bio-assay (urine) sampling will be accomplished for personnel working with unsealed quantities of by-product materials or with any sealed source that develops a leak in excess of 0.005 uc removable.

SUPPLEMENT NO. 4

(Item 13)

Facilities and Equipment

The basic facilities and equipment required for the conduct of the SNAP-21 Fuel Capsule Ocean Exposure Studies consist of:

a. Two exposure shield chambers. These are diagrammed in Figure 2 of LR-67-96. They provide radiation shielding for the fuel capsules during the test and are designed to provide containment of the radioisotope in the event of capsule failure. They have been found to provide enough of a heat path for the thermal energy that capsule temperatures remain below the boiling point of water when the loaded chambers are in a natural convection air environment.

b. A shadow shield handling facility. This is 24 inch concrete wall equipped with manipulator arms and a water viewing window. This is used for radiation control purposes in transferring fuel capsules from and into exposure chambers and shipping containers.

c. Shipping Container. Upon termination of the test the fuel capsules will be removed from the exposure chambers, placed in 2R containers, and returned to the ORNL in the ORNL Uranium Shielded Cask, Model M, for which transport had been previously authorized under NRDL License No. 04-00487-09.

SUPPLEMENT NO. 5

(Items 14 and 15)

Radiation Protection Program

1. Administrative Control

By-product materials will be used under the administration control of the Command Administration Department, NUC, the department housing the RSO and RSO alternate. Responsibilities of this department include the control and accountability of all radioisotope used at NUC. Each experimental use of radioisotope will require the submission, by the experimenter, of a written plan describing the proposed use in detail, including program information, radioisotope, quantities, and forms, personnel and their qualifications, locations of use and procedures. The RSO will review applications, evaluate rad-safety aspects, specify changes in equipment and procedures as required, and provide personnel rad-safety training as necessary. A formal approval will be given the experimenter before use of by-product materials may start.

2. Health and Safety Measures

Specific control measures will include the following:

a. An initial radiation survey will be made for each radioisotope use, followed by periodic surveys of the operation and specifications where materials are used.

b. Aerosol producing operations will be confined to dry boxes and/or ventilated hoods with filtered air exhaust.

c. Personnel will utilize appropriate protective clothing and respiratory protection.

d. Shielding and shielded containers will be used to control radiation levels.

e. Air and wipe sampling will be conducted during and after radioisotope usage.

f. Personnel will be monitored for contamination upon leaving spaces where radioisotopes are used.

g. A sign and marking program will identify the location of radioactive materials and radiation areas.

h. An environmental monitoring program will be conducted to measure radiation levels at the boundaries of controlled areas and concentrations of radioactive material in air and water effluent from controlled areas.

3. Waste Handling Procedures

Liquid and solid wastes will be collected in appropriately marked containers (5 gallon polyethylene bottles for liquid and 30 gallon fiberboard drums for solids). Disposal will be by packaging to meet Department of Transportation specifications and shipment to a licensed waste disposal contractor.

Additional Information Concerning the SNAP-21 Fuel Capsule Environmental Test Program

1. Description of plans for coping with a malfunction, including time log from malfunction alarm to arrival at project personnel, time log for recovery of the system and possibility of operation with safety controls bypassed.

a. The failure alarm associated with the test system for the fueled capsules consists of two lights connected in parallel and mounted on the outside of the shore control station van. These lights are normally in "on" mode, powered through a set of series connected relay contacts within the control circuitry. The opening of one of these contacts extinguishes the lights, thereby indicating trouble in the system. The control circuit of the system is arranged such that any one of the following circumstances will open one or more of the above contacts which will shut down the water pump.

(1) Power failure either in the service system to the van or within the control circuits.

(2) Low test chamber circulating water discharge for whatever reason.

(3) Radiation monitor system malfunction.

(4) Radioactivity in the circulating water at the detector in concentrations in excess of 10^{-4} μc/cc.

The test station is inspected at least twice each day by the resident security guard force who have been instructed to immediately inform project personnel if the trouble lights are "off" or of any other unusual circumstances in connection with the station's appearance. The maximum time interval between alarm indication and project personnel inspection is approximately 40 hours. A similar system is now in operation for other equipment in unattended operation at the test site.

b. There is no foreseeable circumstance or justification for unattended operation of the test system with any portion of the automatic control circuitry bypassed. In order to start the pumping subsystem, it is necessary to bypass the low water switch. This is done through a manual constant pressure switch. However, even with this bypass, the pumping unit will not start unless the circulating water is free of contamination and the monitoring system is in proper working order.

c. In the event of trouble, the nature of which requires that the exposure chamber be recovered, the elapsed time between the decision to recover and the physical recovery of the chamber will vary in accordance with the natur e of the trouble and the availability of the Public Works support required for the recovery. It is estimated that if the trouble involved a radiological hazard, the recovery would be accomplished within 24 hours.

Enclosure (2)

2. Justification of proposed effluent detection limit of 1×10^{-4} µCi/cc.

San Clemente Island Facility is under the jurisdiction of NUC (Naval Undersea Research and Development Center), San Diego, California, and access to the Island is controlled by NUC. The U.S. Coast Guard will declare 300 yards off the pier as restricted waters for boats and personnel. It is, therefore, in a sense a restricted area.

The dilution factor necessary to cut down the effluent detection limit of 10^{-4} µCi/cc to the 10 CFR 20.106 level of 10^{-7} µCi/cc is 1000. With the turbulent motion of the ocean water and thorough mixing action of the surf, such dilution is expected to take place in a very short time and within a very short distance from the water outlet. Applying the Carter-Okubo[1] ocean diffusion model as modified by NRDL[2] indicates that the dimensions of the pool of radioactivity within which concentration exceeds 1×10^{-7} µCi/cc are of the order of a few centimeters in the vertical direction and 1 meter in the horizontal directions. This is still within the 300 yards of our restricted waters.

It is our understanding that the concentration levels quoted in 10 CFR 20 is based on unrestricted areas of potential future use as sources of drinking water. For ocean waters, however, the levels stated in the National Academy of Sciences publication 985 [3] are more applicable. For ^{90}Sr the stated maximum permissible levels in sea water (MPCC) for continuous release is 3.4×10^{-5} µCi/cc. Assuming the acceptability of this standard, the dilution factor required would be $10^{-4}/3.4 \times 10^{-5} = \underline{3.}$

Further, 10 CFR 20.106 states that, "For purposes of this paragraph concentrations may be averaged over periods not greater than one year." As soon as the contaminated effluent stops, the concentration levels at the release point will essentially be down to zero in a matter of minutes. The total time period involved, therefore, is approximately one month during which a maximum of 15 mCi of ^{90}Sr-^{90}Y will be released. A yearly average of the concentration at the water outlet (assuming no dilution at all) will hence be:

$$10^{-4} \text{ µCi/cc} \times \frac{1}{12} = 0.8 \times 10^{-5} \text{ µCi/cc}$$

a value less than that which is recommended by reference (3).

3. Capsule corrosion analysis and leachability of strontium titanate.

The corrosion rate of the encapsulated, Hastelloy C was reported to be 1.5 mils/year (mpy) under exposure conditions of hot seawater-vapor. These conditions are much more severe than the normal expected environmental conditions. However, even at that rate the fuel capsule (0.25 inch thick) has an expected life of 167 years.

As to the leachability of $SrTiO_3$ pellets, according to McHenry [5] the leachability rate starts at about 1 mg/cm^2.day, decreases with time over a period of 2-3 days then increases back to the original rate in about 100 days. Using the initial rate of 1 mg/cm^2 day the amount leached over the 40 hour period in question can be calculated as follows:

Maximum fuel dimensions: length 2.730 inch
Diameter 2.705 inch

Total surface area = 2 II $(1.353)^2$ + 2 II (1.353)(2.730)

$\cong$ 11.5 in^2 + 23.2 in^2 = 34.7 in^2

$\cong$ 223.9 cm^2

The amount leached assuming complete exposure of all fuel surfaces, i.e., complete removal of the Hastelloy Capsule would be:

$$223.9\ cm^2 \times 1\ mg/cm^2\ \frac{day \times 40}{24\ hrs/day} \cong 373\ mg$$

According to ORNL - 4188 (6) the specific activity of average $SrTiO_3$ is 34.8 Ci/gram. The total amount of activity released would be 0.373 x 34.8 = 12.98 Ci.

It should be noticed, however, that under no foreseeable circumstances is it expected that the failure mode assumed above will take place. The most expected mode is the development of a leak in the welds or a crack in the capsule. Under such circumstances the amount of fuel released will be a very small fraction of the 12.98 Ci.

4. Monitoring Equipment.

The minimum radiological monitoring equipment, which we will have on site and available to personnel will be as follows:

Instrument	Type	Quantity on Site	Range	Purpose
CP3D(MS) (Cutie Pie) or similar model	Ionization Chamber	2	0 - 10R/hr	β-γ dose rate monitoring
IM-113 or similar models	Side window G-M	2	0 - 20mR/hr	β-γ dose rate monitoring and contamination detection
Dosimeter IM-9E/PD	Direct reading pocket chamber	5	0 - 200 mR	γ personnel dosimetry
Bendix dosimeter Model 611	Direct reading pocket chamber	5	0 - 5 R	γ personnel dosimetry
Film Badge	Dupont 555 and 1290.5 filter film holder	1/person	25 mR to - 30.00 R	β-γ personnel dosimetry
"Air Sampling Kit" (Gelman R Catalog No. 25002)	--	1	30L/M	Air Sampler

The criteria for taking radiological survey during the transfer operation is to protect personnel and their environment from unwarranted radiation exposure. To accomplish this end, the following steps will be taken during the transfer operation:

a. Personnel Monitoring - Film badges and pocket dosimeters in 0-200 mR and 0-5 R ranges will be worn by all personnel, who are actively involved with the transfer operation.

b. Surface Radiological Monitoring - A minimum of 2 high range (1 R/hr) radiacs will be in use whenever the sources are not in their shielded position. In addition, a health physicist will be in attendance during the entire transfer operation.

c. Radiological aerosol monitoring - The atmosphere in the transfer facility building will be sampled continuously during the transfer. Sampling device, which we will use, is the "air sampling kit". "Staplex High Volume" air samplers will be used for back-up, if necessary. The glass fiber filter samples will be counted in a laboratory type scaler and shielded G-M side window detector.

5. Temperature Analysis

The isolation system has been modified since the original License Application. However, this modification affects the functioning of the system very little. Solenoid actuated valves on the sea water inlet and outlet lines have been replaced with check valves. It was found that if a solenoid valve were utilized in which the solenoid plunger was isolated from the sea water environment, the port would necessarily be so small as to offer an unacceptable resistance to flow since the exposure chamber is placed on the suction side of the pumping system. If a valve were used in which the pressure at the plunger is equalized with the system pressure through the admission of sea water, the plunger would likely corrode and eventually jam in the barrel since the magnetic materials used are not resistant to sea water corrosion.

The check valves will actuate upon loss of flow. Any out of standard parameter will result in interruption of circulation pump power. Accordingly, flow will be prevented from taking place out through the exposure chamber inlet. The exposure chamber outlet is isolated from the ocean through the effluent line. Should the effluent line be cut, the preventative to loss of material from the exposure chamber is the lack of a driving force. The simultaneous release of radioactive material from the test specimen and the cutting of the effluent line is considered a very unlikely event.

The interaction of the thermal conditions of the exposure chamber with the isolation system is such that the functions of the isolation system are not compromised under any expected thermal operating conditions. Steady state temperatures have been calculated for the different surfaces in the exposure chamber under varying operating conditions. These temperatures are listed in Table 1. The variables considered are whether the exposure chamber is in water or in air and whether the chamber itself is filled with water or air.

The release of radioactive materials from the exposure chamber under conditions of isolation must: 1) result from an internal pressure buildup greater than 65 psid and, 2) take place in the vapor state. None of the thermal conditions described in Table 1 can result in both of these conditions being met. The exposure chamber temperatures are not sufficiently high to cause any structural damage to the chamber.

The calculated temperatures of Table 1 do not take into account any added resistance due to marine fouling. Generally, marine fouling of any extent will not be allowed on the external surfaces and none is expected on the internal surfaces. The external surfaces are protected with antifouling paint which has an effectiveness for about one year. Furthermore, it will be examined periodically by divers and maintenance will be performed to remove fouling or renew the paint as required. Fouling is not expected on the internal surfaces because of the internal radiation levels expected. However, significant internal fouling should be detected by an increased flow resistance or by an anomolous internal temperature indication.

Marine fouling is not a uniform material to which an appropriate thermal conductivity can be applied. Under wet conditions it is sufficiently porous to allow convective heat transfer and so result in low thermal resistance under the heat flux conditions of the exposure chamber. Under dry conditions it may result in a porous material having good thermal insulation properties. However, under dry external conditions the exposure chamber will be available for removal of fouling and under dry internal conditions the insulation properties are not important since around 3/4 of the heat is transferred by radiation. If marine fouling could be considered as pure calcium carbonate, a 1/2 inch film would offer around a $5^{\circ}F$ temperature drop on the external wall of the exposure chamber while a 1 inch deposit would result in approximately a $9^{\circ}F$ temperature drop.

Table 1

EXPOSURE CASK STEADY STATE TEMPERATURES

External Environment	Water	Air	Water	Air
Internal Environment	Water	Water	Air	Air
External Environment Bulk Temp., $^{\circ}F$	68	80	68	80
External Cask Surface Temp., $^{\circ}F$	72	220	72	220
Internal Cask Surface Temp., $^{\circ}F$	80	228	80	228
Test Specimen Surface Temp., $^{\circ}F$	128	258	897	1003

6. Check Valve Tests

The action of the check valves will be checked approximately once a month using the following procedure. However, the checkout procedure will show only if one of the two valves is operating and preventing back flow in the line. The material of construction of the check valves is brass, which has good corrosion resistance in sea water and is also antifoul.

Figure 1 is the schematic diagram of the checkout system.

1. Open valve V-2 and flood line L-2 from the discharge of the pump.

2. Close valve V-2 and stop the pump.

3. Open valves V-1 and V-3. This vents the system to the atmosphere, making the line L-1 into a manometer.

4. Visually observe the water level in Line L-2. If the water level remains stationary, then at least one of the check valves is operating. Dropping of the liquid level in line L-2 indicates that both check valves are leaking and in direct proportion to the rate at which the liquid level drops.

5. If no back flow is indicated, close valves V-1 and V-3.

6. Start pump.

7. Structural Analysis

To establish the stresses experienced by the ground tackle and other underwater hardware associated with the placement of the exposure chamber at the test site, it is necessary to establish the maximum wave action to which the underwater structure will be subjected. There are four types of wave action to which the test site could be subjected. The first of these are long or deep water waves, created only by seismic disturbances and referred to as tsunamis. Historical records contain no instance of this area being subjected to this type of wave action. It has therefore been excluded from the consideration due to its improbability. The second and third type of waves experienced in this area are the normal storm generated waves and on more infrequent occasions, storm surges generated outside of the area which are not associated directly with the prevailing area weather. The waves generated under both of these conditions are shallow water waves with a 7 to 8 sec period, approaching the island on which the test site is located from the west and south. The location of the test station on the island affords the station protection from the direct effects of the wave action generated from these causes. The wave action at the location of the test site is materially reduced below that of the direct wave pattern by virtue of the island defraction of the open ocean waves which ultimately arrive at the station location.

SCHEMATIC
CHECK VALVE
OPERATIONAL TEST

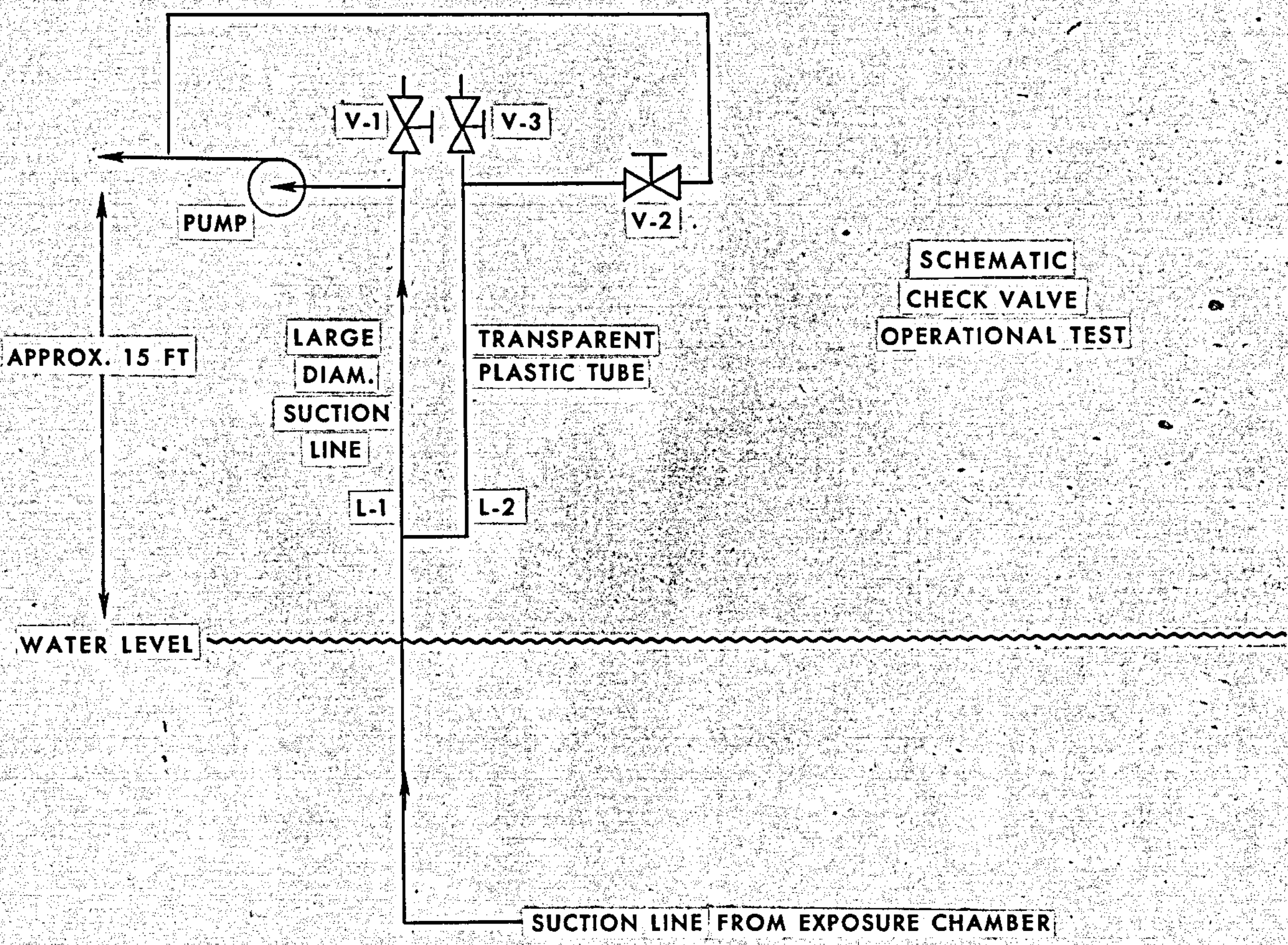

FIGURE 1

MARCH 1968

Historically, the most severe wave action experienced at the test site location is generated by a unique and infrequent storm condition known as a SANTA ANA. The wave conditions created by this type of storm will be used for the structural analysis criteria. This type of storm is characterized in part by high winds, predominatly from the east. This turns what is normally a protected shore at the station into an exposed shore. Winds associated with this type of storm, from the standpoint of surface wave generation, have an average velocity between 30 and 35 mph. over a period of about 10 hours. According to Sverdrup[7] et al, these conditions are sufficient to generate the maximum sea with the fetch of from 60 to 90 miles available to an east wind in this locality. The sea generated under these conditions is characterized by wave heights of about 12 feet and wave periods of about 5 seconds. This corresponds to wave lengths of 128 feet in accordance with the formula

$$L = \frac{gT^2}{2\pi} \qquad \text{(Eq. 1)}$$

The exposure chamber will be suspended immediately below two buoys at a depth of 75 feet. The average depth of the buoys will be 70 feet and will be held at this depth by a concrete clump anchor. The diameter of buoys will be 4 feet and each will have a net buoyancy of about 2000 pounds. For the sake of simplicity and, since the cross-sectional area of these buoys represents the major and most shallow surface upon which the wave action works, the stresses analysis on the system will be confined to those stresses imposed by the wave action on the buoys only, neglecting the small added effect of the chamber and ground tackle. The results of the analysis further justify this simplification.

The solution for water particle velocity within a wave is given by the following formula:

$$v = \frac{2\pi}{T} a e^{-\frac{2\pi z}{L}} \qquad \text{(Eq. 2}^{(7)}\text{)}$$

Where v is velocity in feet/seconds, T is wave period in seconds, z is depth below the undisturbed water level, in feet L is wave length in feet e is the hyperbolic logarithm base (2.718), and a is wave amplitude (1/2 wave height) in feet. However, the values of particle velocity cannot be used directly in the calculation of the wave induced forces on a submerged body in unsteady flow. Equation 2 as well as that for particle acceleration must be introduced into the general equations of forces exerted on such bodies. For fixed submerged objects whose diameter is small compared to the wave length, the horizontal component of force expressed as a function of time is given by Wiegel[8].

$$F_H = -2\pi^2 C_m \rho \frac{V_H}{T^2} \frac{\cosh\ [2\pi(y+d)/L]}{\sinh\ 2\pi\ d/L} \sin 2\pi \frac{t}{T} + \frac{1}{2} C_P\ \rho A \pi^2 \frac{H^2}{T^2} \left(\frac{\cosh\ [2\pi(y+d)/L]}{\sinh\ 2\pi\ d/L} \right)^2$$

$$\cdot \left| \cos \frac{2\pi t}{T} \right| \cos \frac{2\pi t}{T}$$

The vertical component of force is:

$$F_V = -2\pi\rho C_m V \frac{H}{T^2} \sinh \frac{[2\pi(y+d)/L]}{\sinh 2\pi\, d/L} \cos 2\pi \frac{t}{T} + \frac{1}{2} C_P \rho A \pi^2 \frac{H^2}{T^2}\left(\frac{\sinh 2\pi(y+d)/L]}{\sinh 2\pi\, d/L}\right)^2$$

$$\cdot \left| \sin \frac{2\pi t}{T} \right| \sin \frac{2\pi t}{T}$$

Substitution of the test system conditions in the above equations yields a horizontal force component of 110 pounds and a vertical component of 110 pounds. These low values are to be expected since the depth of the buoys is in excess of a half wave length below the undisturbed water surface. Inspection of Equation 2 shows that for short waves such as those that would be experienced at the test site, particle velocities decrease rapidly with depth and are negligible below 65 feet.

The maximum buoyant force on the mooring system will be 4,000 pounds. The stress on the mooring chain between the exposure chamber will be 4,000 pounds less the weight of the exposure chamber (approximately 2,100 pounds). Since the same size fittings will be used both above and below the chamber, the maximum stress resulting from the wave action on the unit will be located between the support buoys and the chamber. This situation serves as a built-in weak link to preclude the separation of the chamber and the anchor. It is highly unlikely that such an occurence would ever take place. The chain has a proof test of 34,680 pounds and a breaking strength of 48,550 pounds. The construction of the buoys, and chamber support frame as well as the miscellaneous hardware in the mooring are either designed or chosen to develop the full strength of the chain. The underwater weight of the concrete clump anchor will be at least 1,000 pounds in excess of the net buoyancy of the remainder of the equipment.

Further, the test exposure chamber has a total weight of approximately 1,700 pounds. This weight will be supported by six brackets welded to the exposure chamber. These brackets are made of 316L stainless steel, the same material as the exposure cask shell. A stress analysis was performed and a minimum allowable load of 3,180 pounds was calculated for each bracket, based on the bearing strength of the material. This value was calculated using an allowable design stress in bearing of 16,000 psi, a value which is a factor of four less than the ultimate tensile strength of 316L stainless. Assuming the exposure chamber is supported by three of the six brackets, the factor of safety based on the design stress would be equal to 5.6.

$$\text{F.S. (design stress)} = \frac{3(3{,}180)}{1700} = 5.6$$

The factor of safety based on the ultimate strength of the material is equal to 22.4.

The exposure chamber will be coated with protective paint to reduce any corrosive action by the sea water to the stainless steel. The rate of corrosion on flat areas of 316 stainless steel in sea water is practically zero; however, pits will develop in unprotected material. The exposure chamber material is protected with antirust and antifouling paint to protect against pit formation. The greatest protection of the exposure cask material against failure due to corrosive action is the use of extremely generous factors of safety.

The only conclusion that can be drawn from this analysis is that the forces on the system resulting from the most severe wave action are small when compared with the static buoyancy forces built into the system by the design, and will have a small effect on the total stress generated in the mooring system. In addition the shear bulk of the system precludes any significant effect of corrosion on the ultimate strength of the system within the projected time period of the test. Generally accepted values for the wasting of carbon steel in sea water range from 4 to 6 mils/year and corresponding values for pitting are 30 to 50 mils/year.

8. Post-Exposure Examinations

There is no planned post exposure examination anticipated for the experiment at this time. However, radiological safety prudence would dictate that we determine the presence or absence of removable radioactivity from the surface of the capsules before shipment to the ORNL.

9. Procedure in the Event of a Ruptured Capsule

In the event that a capsule ruptures during the experiment, transfer to the shipping container will require contamination control measures in addition to the radiation control measures already provided for. Aerosol control features will be added by enclosing the handling facility with plywood or plastic sheeting and by exhausting the enclosure with a blower and filter. Surface contamination control features will be provided by papering all floor areas and establishing a system of controlled entry and exit with monitoring of all personnel and materials leaving the handling facility area. Full protective clothing including respirators will be worn by all personnel in or around the handling facility area. Continuous air sampling will be done in and around the facility during all work with the capsule. In the event of a failed capsule, there will be about 75 gallons of water that may be contaminated with Sr^{90} in the pipeline leading from the exposure chamber to the pump. If the contamination level is no greater than the concentration that will cause shutdown of the system (approximately 1×10^{-4} uc/cc), there should be no particular problem in disposal. The water will be solidified into Department of Transportation specification metal drums with a gelling agent such as diatomaceous earth or cement, sealed and shipped to a waste disposal firm as "low specific activity" waste (limits are 5 uc/ml and 58 mc per container). Should the water exceed the "low specific activity" limits of 5 uc/ml, a carbonate coprecipitation will be performed to produce low specific activity waste. The precipitate will be packaged in Specification 2R container for shipment.

10. Request for Respirator Allowance

We wish to take credit for the use of full face respirators to permit exposure to airborne concentrations in excess of the limits specified in Appendix B, Table I of 10 CFR 20. Accordingly, the following information, as called for in 10 CFR 20 103 (c)(3), is submitted:

(1) The following respirators are available at NRDL:

(a) Mark Five face-mask (standard Navy issue), a molded rubber face-fitting mask, with adjustable straps, plastic eyepiece with two filters of CC-6 cellulose -- asbestos paper, 99.987% efficient for 0.7 micron (median size) methylene blue particles.

(b) M9A1 Face Mask (standard Army issue), a molded rubber face-fitting mask with adjustable straps, plastic eyepiece, with attached canister filter cartridge of CC-6 cellulose-asbestos paper, 99.98% efficient for 0.7 micron particles (median size) methylene blue.

(2) Respirators are fitted to the face by the adjustment of flexible straps, drawing the soft rubber material snugly against the sides of the head. Fit is tested by blocking air passage through the filter and ascertaining that no air can be drawn into the mask past the fitted head part or the flutter valve exhaust port. Maintenance includes inspection for worn parts and their replacement. Filters which are found to contain any radioactivity when monitored are replaced. Respirators are issued on an individual basis and the rubber parts are periodically cleaned by detergent solutions. All masks are thoroughly cleaned with detergent solution before being reissued to other individuals. Indoctrination in using these devices is given to anybody unfamiliar with them. The use and testing of these devices is supervised by health physics personnel until the individual is completely familiar with the device and its operation.

(3) Respirators will be worn only when there is the potential of airborne radioactivity and until the airborne situation can be evaluated by air sampling. Once it is determined that a particular operation does not produce airborne activity in excess of the limits in Appendix B, Table 1 of 10 CFR 20, the respirators will be removed. It is not anticipated that continuous wearing periods of more than one or two hours will be required. The nature of the operation is such that personnel will have the opportunity to leave the airborne radioactivity area for rest periods.

(4) The average concentration expected to be present in areas occupied by employees will be well under 100 times those limits given in Appendix B, Table 1 of 10 CFR 20.

11. Post-test Containment Prior to Shipment

Following recovery of the exposure chamber from the water at the termination of the test, the capsule will be removed from the chamber and transferred to a capsule container. This container will then be shipped to Oak Ridge National Laboratory in the same shipping container previously used to ship the capsule to NRDL.

The 2R capsule container will be fabricated by NRDL and subjected to the drop, puncture, submersion, and thermal tests as specified in Title 10, Part 71, Appendix B of the AEC Rules and Regulations governing the packaging of radioactive material for transport. The integrity of the container will be tested by pressurizing it with helium to 50 psi and testing for leakage by observation of pressure drop and with a helium leak detector.

The capsule container will be used for intact capsules upon completion of the test as well as for a capsule that has failed during the test.

References:

(1) Carter, H. H. and Okubo, A., "A Study of the Physical Processes of movement and Dispersion in the Cape Kennedy Area", Chesapeake Bay Institute, The Johns Hopkins University, Report No. NYO-2973, March 1965.

(2) Mikhail, S. Z., et al., "Development of Ocean Diffusion Models", MRDL-Technical Report in preparation.

(3) "Disposal of Low-Level Radioactive Waste into Pacific Coastal Waters", National Academy of Sciences, National Research Council Publication 985, 1962.

(4) "Compilation of Seawater Corrosion Data for Hastelloy Alloy C", Union Carbide Corp., Stellite Division, Kokomo, Indiana.

(5) McHenry, R. E., "Leach Rate of $^{90}SrTiO_3$ Radioisotopic Power Fuel", Trans. Am. Nucl. Sec. 8(1), 172 (1965).

(6) Rimshaw, S. J. and L. E. Ketchen, "Strontium-90 Data Sheets", ORNL-4188, December 1967.

(7) Sverdrup, Johnson, Fleming, "The Oceans", Prentice-Hall Inc., 1941.

(8) Wiegel, Robert L., "Oceanographical Engineering", Prentice-Hall Inc., 1964.